Issued August 3, 1917.

GUAM AGRICULTURAL EXPERIMENT STATION,

A. C. HARTENBOWER, Agronomist in Charge.

REPORT OF THE GUAM AGRICULTURAL EXPERIMENT STATION.

1916.

UNDER THE SUPERVISION OF

STATES RELATIONS SERVICE,
Office of Experiment Stations,
U. S. DEPARTMENT OF AGRICULTURE.

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GUAM AGRICULTURAL EXPERIMENT STATION, ISLAND OF GUAM.

[Under the supervision of A. C. TRUE, Director of the States Relations Service, United States Department of Agriculture.]

E. W. ALLEN, *Chief of Office of Experiment Stations.*
WALTER H. EVANS, *Chief of Division of Insular Stations, Office of Experiment Stations.*

STATION STAFF.

A. C. HARTENBOWER, *Agronomist in Charge.*
C. W. EDWARDS,[1] *Animal Husbandman.*
PETER NELSON, *Assistant.*

LETTER OF TRANSMITTAL.

GUAM AGRICULTURAL EXPERIMENT STATION,
Island of Guam, June 30, 1916.

SIR: I have the honor to transmit herewith a report of the Guam Agricultural Experiment Station, 1916.

Very respectfully,

A. C. HARTENBOWER,
Agronomist in Charge.

Dr. A. C. TRUE,
Director States Relations Service,
U. S. Department of Agriculture, Washington, D. C.

Publication recommended.
A. C. TRUE, *Director.*

Publication authorized.
D. F. HOUSTON, *Secretary of Agriculture.*

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[1] Appointed July 7, 1916, to succeed L. B. Barber, resigned.

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REPORT OF THE GUAM AGRICULTURAL EXPERIMENT STATION, 1916.

REPORT OF THE AGRONOMIST IN CHARGE.

By A. C. Hartenbower.

BUILDINGS AND REPAIRS.

The buildings constructed during the fiscal year 1915 gave adequate housing for practically all live stock and equipment. However, in addition to necessary repairs, near the end of the present year a ceiled room, 12 by 12 feet, was arranged for feed storage, permitting fumigations for keeping out insects, particularly the grain weevil. Several small buildings, such as individual houses for the buck goats and the boars, were also constructed.

A sewer system was planned and all of the material for its construction was purchased. Heavy rains began on April 15, at least one month earlier than usual, and for this reason it was decided to delay construction until the first favorable season during the fiscal year 1917.

Considerable repair work was done. As lumber, especially on porches and other exposed places, soon decays under Guam conditions, all of the station buildings, roofs as well as sides, were painted, and the small live-stock buildings were given two or more whitewashings inside.

GROUNDS.

About half of the lawn around the office building and the plant houses, approximately one-half acre, was renewed in May. The maintenance of a lawn in Guam is difficult, and without extraordinary care, in three or four years native grasses and weeds replace Bermuda, the only grass found satisfactory for lawn purposes here. The worst lawn enemies are *Andropogon aciculatus* and *Centella asiatica*. Experiments have been begun to determine the most desirable treatment for maintaining a Bermuda lawn and also to study the possibility of restoring a lawn containing large amounts of foreign growth.

Much hoeing and weeding is necessary to keep grass and other growths from covering the cascajo roads and walks on the station grounds. These cleanings have made resurfacing necessary every year. During the year all roads and walks were resurfaced. The efficiency of an arsenical spray for weed control having been demon-

strated, it is hoped the spraying will so keep down growths that, hereafter, resurfacing will not be necessary oftener than every two or three years.

Different varieties of hibiscus and other ornamental plants have been freely planted on the grounds during the past two years. All odd corners and backgrounds on the lawn have been planted to ornamental plants in order to reduce the expense of maintaining Bermuda grass. The various groups have added much to the beauty of the grounds and some have attracted especial attention. A plant of *Bougainvillea spectabilis* introduced in 1911 has made noticeable growth, and so many visitors have desired cuttings that it is hoped that the station will be able to distribute them during the next year.

LIBRARY AND CORRESPONDENCE.

During the year 130 volumes of books and bound station publications relating to agriculture have been added to the library. The isolation of Guam makes a comprehensive library of the utmost importance, and such a library is being built up here as fast as funds will allow. Bulletins and publications from many foreign countries, particularly those having conditions similar to those at Guam, as well as from experiment stations and other institutions in the United States, are now regularly received.

The correspondence and the number of requests for publications of this station have shown a substantial increase.

VISITORS.

The number of visitors at the station during the past year has been fully treble that of any previous year. This is pleasing as it indicates a greater interest on the part of the people of the island in the work carried on.

AGRONOMICAL INVESTIGATIONS.

The crop studies have proceeded satisfactorily and in some cases permit of conclusions being drawn. In all tests, except those of Para grass and *Paspalum dilatatum*, the plats used have been small, owing to the relatively small area of land available at this station. The largest plats used for the intertilled crops were each four-tenths of an acre, while some of the plats were as small as one-twentieth of an acre each. Duplicate plats were used wherever possible.

CORN.

Improvement work.—The corn improvement work begun during the season of 1915 was continued. As was noted in the last annual report, an attempt is being made to develop a higher yielding, higher quality strain of corn than that now grown.

The first planting for the year was made on June 15. Owing to the lack of rain, the corn did not come up until July 14 and the stand obtained was poor. Selections were made from the six best rows, all of which rows came from row No. 4 of the previous planting.

In the planting made on December 6 for the second crop of the year, ears from the previous planting which most nearly met the requirements were planted. The rows were 3 feet apart, and each contained approximately 80 plants. Selections were made on February 12 and all of the corn was harvested on February 29. The best row, which was planted with seed from row No. 4 of the previous test, gave 34 selected ears, while the poorest row gave only 14 selected ears.

On April 15 a third planting of 28 rows was made, all from the best yielding row of the December 6 planting. An excellent stand was obtained, and at the close of the time covered by this report the corn was in the hard dough stage. Visitors during the past season who saw the corn improvement plat during the maturity of the earlier crops, without exception said that the ears of corn were far superior to any they had ever seen in Guam. Several requests were made for seed, but it was not deemed advisable to begin distribution at so early a date. One exception was made, and, under cooperative agreement, seed was given to Mr. R. C. Gibson, in charge of the Naval Government Farm. Selected seed ears, from third and fourth highest yielding rows of ears that met the requirements from the second planting of 1916, were given him for ear-to-row breeding to be continued under his charge. If success attends this effort, it will not only provide more seed for ultimate distribution, but also will serve as an object lesson to native ranchers in the vicinity of Agana, Guam.

Variety tests.—Corn of the Yellow Dent and Chisholm varieties from Texas and of a white variety from Hawaii was planted on January 8. The Yellow Dent and the Chisholm varieties failed to set ears, while the Hawaii corn produced a few small inferior ears. Seed of the latter corn was planted in April to determine its production during the present season.

COTTON.

First ratoon crop.—On June 8, 1915, Egyptian and Columbia cotton plants from Hawaii seed and Covington-Toole plants from Alabama seed, used in the variety test of the second season of 1914, were heavily pruned and left in the plats to study the ratoon crops produced (Pl. I, fig. 1). The yields obtained from the first ratoon crop are shown in the table following.

Yields of seed cotton produced by first ratoon crop.

Type.	Variety.	Number of pickings.	Dates of picking.	Yield per acre.
				Pounds.
Upland	Covington-Toole	7	Nov. 11, 1915, to Mar. 15, 1916	1,012
Do	Columbia	7	do	1,137
Egyptian	Gila	5	do	301

These plats of cotton are located on heavy soil. When this soil is wet, moderate winds will upturn tall plants growing in it. The Egyptian cotton was particularly injured by winds, and by September 15 every plant was blown over and distorted. These never recovered and this largely accounts for the low yield obtained. Though the Covington-Toole and the Columbia varieties were injured, they soon recovered.

Blossoming began on the Covington-Toole and the Columbia varieties the last week in August. Maturity was very irregular, and in order to prevent a considerable part of the cotton from falling to the ground, many pickings were required. None of the cotton produced would have graded above low middling, as it was off-colored, tinged, and stained, and contained considerable dirt. The fiber produced was weak.

First crop of 1916.—The first planting for the 1916 crop included 3 varieties of Upland short staple, 2 of Upland long staple, 3 of Egyptian, 3 of Sea Island, and 1 of Caravonica cotton. Results, as far as they are available from this planting, are given below.

Yields of seed cotton from planting made June 22, 1915.

Variety.	Number of pickings.	Dates of picking.	Number of bolls per pound seed cotton.	Yield per acre.
				Pounds.
Cook's Improved	8	Dec. 24, 1915, to Apr. 11, 1916	94	1,478
Covington-Toole	8	do	112	1,423
Triumph	8	do	93	1,382
Blue Ribbon	5	Feb. 5 to Apr. 11, 1916	78	1,067
Hartsville	5	do	78	1,820

Aside from those reported in the above table, none of the varieties produced a crop except the Pima variety of Egyptian cotton, which gave only a few pounds. Heavy winds during the wet season completely ruined the Sea Island, the Caravonica, and two varieties of the Egyptian cotton. Many of the plants were so nearly blown from the soil that they died and the others were so badly injured that they did not produce any crop (Pl. I, fig. 2). Many plants of the Upland varieties were blown over but they recovered quickly.

The grade of cotton produced from this planting was low as compared with that of the cotton grown during the dry season. The fiber from the last as well as from the first pickings was weak.

Second crop of 1916.—Only five varieties were planted during the second season, the seed of one of which, Sea Island, failed to grow. The data obtained are summarized in the following table:

Yields of seed cotton from planting made Dec. 7, 1915.

Type.	Variety.	Dates of picking.	Number of bolls per pound seed cotton.	Average length of fiber.	Yield per acre.
		1916.		*Inches.*	*Pounds.*
Upland	Covington-Toole	Apr. 11, Apr. 25, May 6	91	0.90	1,479
Do	Columbia	do	89	1.10	1,287
Do	Hartsville	do	63	1.25	1,754
Egyptian	Gila	Apr. 25, May 18, June 7		1.37	571

In the case of the Egyptian cotton obtained from Hawaii, no stand was obtained, and the plat was replanted on December 27 with Arizona-grown seed. The growth of the first three varieties named was excellent, and the quality of the cotton produced was high, not only in grade but also in fiber. That from the Egyptian was poor as compared with that produced during the fiscal year 1915.

The Covington-Toole, Columbia, and Hartsville plants were pruned heavily on May 8, after the last picking, in order to determine the value of a ratoon crop from each of them. The Egyptian picking was not over until June 7, when that variety was also pruned.

Summary.—It is believed that the following conclusions from the cotton work to date are justified by the accumulated data:

(1) Planting cotton in Guam at the end of the dry season, about May 1 in normal years, is unprofitable. There are excellent reasons for this conclusion. The ground is so occupied that the production that year of any other crop, as corn, is impossible in a field so planted. If the cotton matured sufficiently early in the next dry season to produce a ratoon crop that season, it might prove profitable, but such is not the case. The harvesting of cotton planted June 22 was completed only three and one-half weeks before that of cotton planted December 7 following. The later crop will more nearly produce an even maturing and high quality ratoon crop than will the earlier. This is shown by notes taken on June 14, 1916. At that time the ratoon crop from the December 7, 1915, planting had half-matured bolls, while the ratoon crop from the June 22, 1915, planting was only in bloom. Cultivation during most of the

rainy season is an impossibility. At this station the only satisfactory method found for keeping down weeds in the cotton was the use of an arsenical spray, and this was difficult because of almost daily rains. Eight pickings, completed in three and one-half months, were required from the June planting, and three, covering three and one-half weeks, from the other, some cotton being lost in the first case. Cotton planted at the end of the dry season was extremely slow in maturing, while the other was quick. In the first crop the grade was low and the fiber was decidedly weak, while in the latter crop such conditions during maturity as dry, hot weather made for strong-fibered cotton of the highest possible grade.

(2) The ratoon crop above referred to took two seasons to be produced. Two crops were obtained from one planting in three seasons. The dry season of 1915 was exceptionally long, while that of 1916 was short. It appears probable that a profitable ratoon crop will be obtained from the planting made on December 7, 1915.

(3) The results obtained from Egyptian cotton during the past year are discouraging when compared with those obtained in 1915. In this comparison two points in particular must be considered—first, the source of the seed used, and, second, the date of planting. The 1915 crop was planted on December 19, 1914, with Hawaii seed, while the 1916 crop was from the December 27 planting with Arizona seed. Late planting of Arizona seed resulted in a low yield of cotton of inferior quality in 1915, whereas early planting of Hawaii seed the same season gave an exceptionally high yield of cotton of superior quality. These results were about duplicated in 1916. Further experimental work is necessary before a definite value can be given to Egyptian cotton in Guam.

(4) Sea Island cotton and Caravonica cotton have proved unsatisfactory in all tests.

Notes on cotton growing throughout the island.—Ten bushels of Egyptian cotton seed from Arizona were distributed in November, 1915, through cooperation with the naval government of Guam. Observations and reports on the cotton have been generally satisfactory, the growth being much better than that obtained at the station with similar seed. Doubtless the time of planting was a deciding factor. Especially good reports have come from the south end of the island.

Steps have been taken toward providing ginning facilities, and it is believed that something tangible will soon come from this introduction.

While the land available for growing cotton is relatively small in area, yet cotton appears to be an excellent addition to the list of Guam crops. This is well expressed by Mr. Vicente Torres, of Merizo, Guam, who says: "Cotton makes a crop that the native can

get money for. It ranks with coconuts. I am urging the ranchers in my vicinity to grow it along with their coconuts, plantings made at the beginning of the past dry season having been so successful."

RICE.

Rice was widely grown in Guam before the discovery of the island by Magellan. At that time the area devoted to its culture was much larger than at present. The decline in rice production here has several causes, but probably most of it is due to the uncertainty of the crop and to the increased amount of public work. The former element was well illustrated during the past season when heavy northeast winds from December 30 to January 16 reduced the yield by at least two-thirds, if the evidence of native growers is conclusive.

The native methods of growing rice are essentially primitive. The first step is the preparation (generally on the richest land) of a nursery for the propagation of the seedling plants, which, when some four weeks old, are about 6 inches high and are ready to be transplanted in the regular field. Before being planted in the seed bed the seed is placed in sacks and soaked in water for 12 hours and left in the sacks for three days, or until sprouting commences. The nursery bed is planted with the sprouted rice and is kept well under water until the young plants are ready to be transplanted.

The preparation of the regular field is made before the nursery is started or while the seedlings are growing. Usually all cultural operations are carried out while the field is submerged. In Guam the field is first of all well plowed and then gone over at least twice with a tool called a "panie." This tool is made of steel, has about 12 teeth, and looks very much like a horse weeder. It is used especially to clean the field of weeds, although it levels as well. The water is then withdrawn for about two days. Before transplanting, about one-third of the top of the seedling is cut off. The seedlings are planted in bunches of five or six approximately 5 inches deep in the mud and 1 foot apart each way. The fields are then kept flooded—that is, if the water supplied by the streams is sufficient—until the rice grains are well developed, when the water is drawn off. Machetes, or bolos, are used in the hand harvesting. The rice is generally thrashed on the day of harvesting by beating small bundles of the plants over a bamboo pole. The wind serves as fanning mill. The rough, or unhulled, rice is then stored away to be hulled as needed.

Fertilizer tests.—The tests undertaken by this station the past season were made in the rice fields of Mr. Joaquin Diaz, of Piti, who grows about 6 acres of rice each year. He was rather dubious about permitting the station to apply fertilizers over a section of his field,

but consented when assured that his land would not be injured. The following table gives fertilizer treatments, number of tillers, average height, and yields obtained:

Results of fertilizer experiments with rice.

Fertilizer treatment per acre.	Number of tillers (average of 12 counts in each plat).	Height of plants.	Yield per acre of rough rice.
		Inches.	*Pounds.*
Nitrate of soda, 266 pounds	33	43	652
Acid phosphate, 166½ pounds	24	46	674
Sulphate of potash, 95 pounds	29	35	1,087
Nitrate of soda, 236 pounds; acid phosphate, 166½ pounds; sulphate of potash, 95 pounds	24	45	783
Nitrate of soda, 266 pounds; sulphate of potash, 95 pounds	22	39	957
Acid phosphate, 166½ pounds; sulphate of potash, 95 pounds	22	35	600
Acid phosphate, 166½ pounds; nitrate of soda, 266 pounds	40	37	409
Unfertilized, or check plats	19	31	259

The fertilizers were carefully mixed and applied September 20, 1915. Water was withdrawn from the plats two days before the applications and was not turned in again until four days after. The rice seedlings were transplanted on September 24, 1915.

On December 26, the rice was starting to head out on all plats to which acid phosphate had been applied, either alone or in combination, and also on the unfertilized, or check plats. On January 6, the rice was starting to head out on plats to which had been applied nitrate of soda alone, sulphate of potash alone, and nitrate of soda and sulphate of potash in combination. On February 7, all plats were harvested except those to which had been applied nitrate of soda alone, sulphate of potash alone, and nitrate of soda and sulphate of potash. These were not harvested until February 15.

At the time of harvesting, the acid phosphate and nitrate of soda, acid phosphate and sulphate of potash, and unfertilized plats were very badly lodged, fully one-half of the plants on the first of these plats being down. The plats with acid phosphate alone and those completely fertilized were lodged somewhat. None of the plats harvested on February 15 were lodged to any extent. As has been noted previously, from December 30 to January 16 high winds from the northwest prevailed. The rice on all plats which started to head in December was badly damaged and considerable lodging resulted.

The highest yielding fertilized plats gave more than four times as much as the unfertilized plats, while the lowest yield from a fertilized plat was only a little less than twice that of the unfertilized plats. It would appear that the large yields from the sulphate of potash and the nitrate of soda plats can be traced to the late date of maturity, or to the longer growing season, which enabled the rice on those

plats largely to escape being blasted by the high winds in December and January. During the next season this experiment will be duplicated and extended over a larger area.

Variety test.—Seed of 8 varieties of rice, 7 from Hawaii and 1 from Porto Rico, was planted in a seed nursery on August 15. Five failed to grow and were replanted on August 25, with the same result. The three varieties that grew were Hawaiian Gold Seed, See Miu, and Porto Rico. The first two varieties grew well in the nursery, while at transplanting time the plants of the last were still very small.

The varieties were transplanted in the Diaz rice field on September 25. All plats were small, approximately one-thirtieth of an acre, and no duplicate plats, except of the native rice, were grown. None of the plats were fertilized. The rice on all plats was harvested on February 7, and the amount of rough rice, calculated to acre yields, was as follows: Plat 1, native rice, 364 pounds; plat 2, Hawaiian Gold Seed, 122 pounds; plat 3, See Miu, 704 pounds; plat 4, Porto Rico, 105 pounds; and plat 5, native, 324 pounds.

The three imported varieties commenced to head on November 29, about three weeks earlier than did the native rice. At harvest the crop on plats 1, 2, and 5 was badly lodged, on No. 2 particularly so, while that on plats 3 and 4 lodged very little. The rice on all plats was badly injured by high winds from December 30 to January 16. Comparative tests of Guam-grown and imported seed of the above three varieties are planned for next year.

ALFALFA.

From the information obtained during the fiscal year 1915 it appears that two or three unsuccessful attempts had been made to grow alfalfa on this island. Since the cause of the failures was undetermined, it was deemed advisable to find whether they were due to inferior cultural methods or to natural forces.

Four varieties or strains of alfalfa seed—namely, Peruvian, Grimm, Black Hills, and Kansas grown—together with a supply of cultures of alfalfa bacteria, were obtained from the Bureau of Plant Industry of this department. Low, heavy clay soil, fairly well drained, was chosen for the test. The land had produced cowpeas in the first season of 1915 and was in excellent physical condition. It was plowed about 5 inches deep, harrowed, and then pulverized. The seed bed obtained was well pulverized, weed free, and compact. Four plats, numbered from 1 to 4, inclusive, each 66 feet by 28 feet in size, were laid out. Each plat was divided into four parts and each part given the following treatment: Section a, inoculated; b, inoculated and fertilized; c, fertilized; and d, untreated or check. The fertilizer was

applied at the rate of 100 pounds of nitrate of soda, 200 pounds of acid phosphate, and 50 pounds of muriate of potash per acre.

The seed was planted on January 7. Timely showers sprouted the seed promptly and an excellent stand was obtained on all plats. The Peruvian and Kansas-grown plats, in particular, made a quick start and, by March 15, when the plants were approximately 1 foot high, they showed blossoms. The weather at that time was very dry and the soil cracked open, cracks 2 inches wide occurring generally in all plats. The plats were clipped high on March 27 and the cut-off stems left on the ground.

The first heavy rain of the season came on April 15, and from then on the alfalfa grew rapidly. Between April 15 and June 30 two cuttings from plat 1 and one cutting from each of the other plats were obtained, and the yields from areas 14 by 33 feet are given in the following table:

Effect of inoculation on the growth of alfalfa.

Plat section.	Variety.	Treatment.	Date of harvesting.		Yield of green alfalfa.	
			First crop.	Second crop.	First crop.	Second crop.
					Pounds.	*Pounds.*
1a	Peruvian	Inoculated	May 24	June 26	65.5	62.0
1b	do	Inoculated and fertilized	do	do	75.5	61.0
1c	do	Fertilized	do	do	56.5	31.5
1d	do	No treatment	do	do	33.0	21.5
2a	Grimm	Inoculated	June 12		15.0	
2b	do	Inoculated and fertilized	do		39.0	
2c	do	Fertilized	do		26.5	
2d	do	No treatment	do		11.0	
3a	Black Hills	Inoculated	do		22.5	
3b	do	Inoculated and fertilized	do		35.5	
3c	do	Fertilized	do		21.0	
3d	do	No treatment	do		15.5	
4a	Kansas grown	Inoculated	do		42.5	
4b	do	Inoculated and fertilized	do		51.5	
4c	do	Fertilized	do		35.5	
4d	do	No treatment	do		24.5	

While the field selected for this test is well drained when compared with most of the lowlands of Guam, yet there are times after heavy rains when the water does not drain from the plats promptly. During the month of May the total rainfall was approximately 23 inches, probably as much as would occur in any month of a normal year. The alfalfa has so far apparently escaped injury, and this promises well for the future. It will be only from the results of the entire coming rainy season that any real estimate may be made of the adaptability of alfalfa to Guam conditions. To date, the Peruvian alfalfa appears to be better adapted to the conditions than any of the other varieties or strains. Neither Grimm nor the Black Hills strain has grown well.

TOBACCO.

Seed of White Burley, Oronoco, Connecticut Broadleaf, Connecticut Havana, Yellow Pryor, and Cuban tobacco was furnished to this station by the Office of Tobacco Investigations of this department. The seeds were planted in flats; and on January 6, when the plants were about two months old, they were transplanted to their permanent places.

Plats 12 by 100 feet were fertilized at the rate of 320 pounds of nitrate of soda, 320 pounds of acid phosphate, and 120 pounds of sulphate of potash per acre one week before planting. The plants were placed in rows 3 feet apart, with 18 inches between the plants in the row. The transplanting was done on a cloudy day with a drizzling rain falling. On January 7 the weather turned off dry and continued so for two weeks. During that time the plants were regularly watered, but many of them were lost. Of the Yellow Pryor and Cuban varieties so few plants remained that their records of production will not be considered in the following discussion. In all cases it was necessary to consider the number of plants rather than the area in tobacco of each variety in arriving at production. Three cuttings were made, on April 13, April 28, and May 12. Curing was done in the station barn, the only place available. Data were obtained on the value of varieties and on the effects of fertilizers, of shading, and of treating with lead arsenate for insect control.

Yields of cured tobacco.—The highest yield per plant from unshaded tobacco was 11.14 ounces of White Burley on fertilized plat 2, and the lowest yield was 3.5 ounces of Connecticut Broadleaf on unfertilized plat 3. For varieties, the average yield per plant from the fertilized and unfertilized plats was Oronoco, 7.2 ounces; White Burley, 9.7 ounces; Connecticut Broadleaf, 5.8 ounces, and Connecticut Havana, 5.2 ounces. The shaded plants of the White Burley and the Oronoco gave an average of 48.6 per cent less tobacco per plant than the unshaded plants on the same plats. The treatment with lead arsenate resulted in increasing the yield 7.4 per cent.

Effect of fertilizers on yields.—On the unshaded plants, fertilizers gave an average increase in production of 21.88 per cent; and on the shaded plants an average increase of 10.1 per cent. The soil of the tobacco plats had not been cropped for several years, and this largely accounts for the small increased production from the fertilizers. No heavy rains came after the fertilizer was applied, and this also was doubtless an important factor.

Insect enemy studies,—The most serious pest of tobacco in Guam is the bollworm (*Heliothis obsoleta*). This insect feeds especially upon leaves and buds and not only reduces the yield but also disfigures

the leaves. In fields on native ranches only occasionally is an entire leaf found.

With the object of reducing the injury from this insect, a small quantity of a mixture of 7 parts of corn meal and 1 part of powdered lead arsenate was sprinkled once each week during the growth of the crop upon the terminal buds and the upper leaves of one-half of the tobacco plants under test. This was done with shaded and unshaded plants alike (Pl. II). In order to determine the value of the lead arsenate treatment, the leaves produced were divided into four grades: Grade 1, perfect leaves, or those with no holes in them; grade 2, leaves containing six or fewer holes one-half inch or less in diameter; grade 3, leaves with undamaged outlines but containing holes larger than those of grade 2; and grade 4, all leaves not meeting the requirements of the other grades. The results obtained may be summarized as follows:

Effect of lead arsenate treatment on unshaded and shaded tobacco.

	Leaves from unshaded plants.				Leaves from shaded plants.			
	Grade 1.	Grade 2.	Grade 3.	Grade 4.	Grade 1.	Grade 2.	Grade 3.	Grade 4.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Treated	12.3	19.4	16.3	52.0	29.3	26.5	18.5	25.7
Untreated	9.4	13.0	13.7	63.9	10.3	16.7	17.3	55.7

In comparing the shaded plants not treated with lead arsenate with those unshaded and untreated, the following results were obtained:

Effect of shading on quality of leaves.

	Grade 1.	Grade 2.	Grade 3.	Grade 4.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Shaded	20.0	20.8	15.2	44.0
Unshaded	8.5	11.7	12.5	67.3

COWPEAS.

Soil inoculation test.—An examination of cowpea roots on the station farm during the fiscal year 1915 showed no nodular growths. Consequently, inoculation material was obtained from the Bureau of Plant Industry of this department, and was used in a test with cowpeas the first season of this past year.

On June 23, 1915, two days after the inoculation of the soil, cowpeas were planted. A similar uninoculated field was also planted. The cowpea pods were hand-picked twice, the last picking being made on October 5 just before the vines were mowed. From the inoculated and uninoculated fields, the yields of grain per acre were

FIG. 1.—COTTON PLANTED DECEMBER 10, 1914, PRODUCING SECOND RATOON CROP.
Photographed June 8, 1916.

FIG. 2.—EFFECT OF HIGH WINDS ON EGYPTIAN AND SEA ISLAND COTTON.

FIG. 1.—ORONOCO, SHADED.
Fertilized and untreated, fertilized and treated, unfertilized and treated, unfertilized and untreated.

FIG. 2.—ORONOCO, UNSHADED.
Fertilized and treated, fertilized and untreated, unfertilized and untreated, unfertilized and treated.

FIG. 3.—CONNECTICUT-HAVANA, UNSHADED.
Fertilized and treated, fertilized and untreated, unfertilized and untreated, unfertilized and treated.

EFFECT OF FERTILIZERS AND ARSENATE OF LEAD ON TOBACCO.

885 and 808 pounds, respectively, and of green forage, 15,125 and 9,790 pounds, respectively.

The roots of several plants from inoculated and uninoculated plats were carefully freed from soil, and examination showed that while, without exception, those grown in inoculated soil were well covered with nodules, those from uninoculated soil showed only an occasional nodule.

The yields in this test go far to prove the value of inoculation of soils for cowpeas in Guam. It appears to be useless to expect the highest yields without inoculation. During the year other fields were successfully inoculated with soil from the plats first inoculated.

Other tests.—Three plantings of cowpeas were made on side-hill land, one on November 20, another on December 20, and a third on January 15. The November 20 planting alone formed pods, and that only a few, a lack of moisture doubtless causing the failure of grain. The vines were used for hog pasture, and a more detailed report upon their use for that purpose will be found in the report of the veterinarian and animal husbandman. (See p. 52.)

A planting was made in a lowland field on January 10. The first picking of peas was made on March 22 and a second on April 11. The total yield obtained was at the rate of 4.01 bushels of grain and 4,099 pounds of green vines per acre.

The work during the past two years has served to show that of the leguminous crops thus far tested the cowpea is the most promising as a rotation crop, hog pasture, and, with velvet beans and possibly jack beans, as a grain crop for giving a nitrogenous feeding stuff to use in grain rations for hogs and chickens.

The ability of the cowpea to improve the physical condition of soils was strongly shown in the field where the inoculation test was made. Previously, efforts had been made to obtain a well-pulverized seed bed for alfalfa in that field but with poor success, and only after growing the cowpeas was an excellent pulverization obtained.

Two trials were made to grow ratoon crops of cowpeas, but they were not successful.

SOY BEANS.

The results obtained with soy beans in the past year were far from satisfactory. Three plantings were made in June, 1915, with seed testing 80 per cent germination, yet no stand was obtained in any case. Observations showed that some undetermined insect enemy destroyed the plantlets of the last planting just as they were coming through the soil.

Plantings were also made on November 20 and December 10 on side-hill soil. Good stands were obtained, but the plants did not

make satisfactory growth, and the estimated yield of grain was only 4.5 bushels per acre from the first planting. Further tests are needed before definite conclusions can be reached.

PIGEON PEA (*Cajanus indicus*).

The seed for growing pigeon peas at this station the past year was obtained from the Hawaii Experiment Station. Plantings were made on December 7 and 31. To date, no seeds have been produced, though the plants have attained heights of 9 and 7 feet, respectively.

The pigeon pea appears to be particularly valuable in Guam as a temporary windbreak for orchards, gardens, and even field crops, especially corn, during the rainy seasons (Pl. III, fig. 1). It seems to have no insect enemies of importance.

VELVET BEANS.

During the year the following varieties of velvet beans were tested: Florida velvet bean (*Stizolobium deeringianum*), Mauritius bean (*S. aterrimum*), Lyon bean (*S. niveum*), and velvet beans from Porto Rico (probably *S. velutinum*).

The first plantings of Florida velvet beans and Porto Rico velvet beans were made on lowland in June, 1915. By September 15 the vines covered the ground on both plats. Measurements made on October 30 showed an average length of vines of 8 feet for the Porto Rico beans, about twice that for the Florida beans. The Florida beans were harvested on January 11 and yielded at the rate of 14.3 bushels of grain and 7.3 tons of green forage per acre. The first seed was harvested from the Porto Rico beans on April 11. The vines were not harvested, but were left to produce a ratoon crop.

Plantings of Mauritius, Lyon, and imported and Guam-grown Florida velvet beans were made on December 7, 1915. The following table gives the results obtained from this test:

Results of a comparative test of velvet beans.

Name of variety.	Date of harvesting.	Days required to mature.	Average growth of vines.	Yield of grain per acre.
			Feet.	*Bushels.*
Mauritius bean	Apr. 19 to May 11	158	6.5	8.2
Lyon bean	do	158	5.75	4.6
Florida velvet bean (Guam-grown seed)	Apr. 5	116	3.5	11.4
Florida velvet bean (imported seed)	do	116	3.0	9.5

The velvet bean is a valuable addition to the list of leguminous crops that can be successfully produced in Guam. This is particularly true when it is considered for use as a cover crop and possibly for grain production. The Florida variety appears to be best for

grain. It is relatively quick of growth and even in maturity, especially if planted about December 1. For use as a cover crop it appears to be far inferior to any of the other varieties.

For keeping down weed growths during the wet seasons, the velvet bean appears to be superior to any other crop tried, with the possible exception of the jack bean. Plantings of all of the above velvet bean varieties were made again on April 19, principally for the purpose of studying their value as orchard cover crops during the wet season.

JACK BEAN (*Canavali ensiformis*).

A planting of jack beans was made on December 7. The first harvest of beans was made on May 24 and a second on June 9. The beans are still producing at this date.

The average height reached by the plants was 38 inches, and the first pods produced averaged 11 inches in length. The plants completely covered the ground and acted as an excellent soil-holding, weed-smothering, and soil-improving crop (Pl. III, fig. 2).

KAFIR, FETERITA, AND MILO.

First season trials.—The first plantings of kafir and feterita were made on lowland on June 24, 1915, but no stand was obtained. Success attended the plantings on the same plats on July 16. Harvesting was delayed beyond the time normally required for maturity, as it was hoped to obtain a grain yield. The glumes failed to fill, and the fodder, with heads containing an occasional kernel, was harvested on October 15. The yields of forage on an acre basis were: Feterita, 22,700 pounds; kafir, 12,501 pounds. All fodder was of excellent quality. Doubtless the heavy rains during the growth of the crops account for the failure of the glumes to fill.

The feterita stubble was not removed after harvesting, but was left in order to determine the yields from cutting ratoon crops. The following table gives the yields that have been obtained:

Yields of successive cuttings of feterita.

Number of cutting.	Date of cutting.	Acre yield.	
		Grain.	Stover or fodder.
		Bushels.	*Pounds.*
Second	Dec. 15	.....	19,199
Third	Mar. 22	10.8	4,612
Fourth	June 9	9.8	11,416

The feterita stover, or fodder, from the above cuttings was used as a soiling crop for hogs, it being deemed best not to attempt to use it as a feed for cattle or goats.

Second season trials.—During the second season four plantings of feterita and three each of kafir and milo were made. The first planting of all three crops was made on relatively high, but fairly good, side-hill land on November 20. The milo and the feterita, which were harvested on February 16, and the kafir, on March 5, gave yields of grain at the following rates per acre: Kafir, 13.2 bushels; feterita, 11.4 bushels; and milo, 9.3 bushels. No record of the stover weights was kept. A second planting was made on December 10 in another part of the field. The milo and the feterita were harvested on March 7, and the kafir on March 30. The crops yielded grain at the following rates per acre: Kafir, 9.1 bushels; feterita, 7.8 bushels; and milo, 6.8 bushels. These data appear to show the absolute necessity of early planting of grain sorghums on the higher lands. Another important fact brought out was that much of the poor side-hill land, at present producing only native grasses, will give fair yields of the grain sorghums. Whether these lands should be so cropped or changed to *Paspalum dilatatum* grass pastures remains to be determined.

On January 10 these grains were planted in a lowland field where the seed of other crops planted earlier in the season had failed to give stands. This field is recognized by the natives as good corn land. The soil is heavy and while almost impervious to the entrance of moisture yet holds well any moisture that enters. That all of the grain sorghums crops did well is shown by the following yields of grain and stover:

Yields of grain and stover from kafir, feterita, and milo.

Name of crop.	Date of harvesting.	Acre yield.	
		Grain.	Green stover.
		Bushels.	*Pounds.*
Black-hulled kafir	Apr. 21	23.56	7,995
Feterita	Apr. 18	18.18	8,038
Dwarf Yellow milo	Apr. 11	15.70	5,628

The kafir and feterita crops produced by this planting were exceptionally good, if judged by former tests of them at this station. The heads were large and well filled. Milo in this trial, as well as in the earlier ones, did not show up well when compared with kafir and feterita. Not only was the stover yield low, but the grain yield was about 8 bushels per acre less than that of kafir, unpromising results for the future of milo in Guam.

Counts made on suckering and side-branching showed that each feterita plant averaged three suckers and two side branches; milo, one sucker and one side branch; and kafir, only occasional side

branches or suckers. When the feterita was harvested, about 25 per cent of the heads were not past the flowering stage, and the maturity was most irregular. With kafir and milo, on the contrary, maturity was regular and there was an exceptionally even height of plants in each case.

In the fourth test, feterita alone (one plat) was planted on good side-hill land on January 27. This crop was harvested on April 27 and yielded at the rate of 5,902 pounds of fodder per acre. Almost no kernels were formed in the glumes, although the crop was left unharvested for fully one week after the few kernels found had matured. Whether the failure of the heads to fill was due to scarcity of moisture, to heavy winds, or to lack of plant food in the soil, or to all of these causes combined, was not settled by the test.

The work thus far has shown the great value of kafir and feterita as soiling or grain crops. For the latter use they should be particularly valuable for poultry raisers. The scarcity of insect enemies, the wide adaptability of the crops, and their relatively high yields should lead to their more extended use over the island.

PARA GRASS (*Panicum barbinode*).

During the last year four lines of investigation were undertaken with Para grass—that is, fertilizer and plowing tests, methods of planting, pasturage possibilities, and value for feeding to stabled horses as compared with alfalfa hay as a check.

Experiments in renovating Para grass fields.—A field of approximately 3 acres was chosen for this work and planted in 1911. An application of nitrate of soda was made in 1913, but there are no data available as to the amount applied or its effect. During the fiscal year 1915, it was noted that the production was rapidly declining and that weeds and native grasses were making inroads upon the stand of the Para grass. The field was consequently laid out in 8 plats for experiment. The following table gives the number of cuttings, treatment of each plat, and yields per acre for the year:

Yields of green forage from treated and untreated plats.

Plat No.	Number of cuttings.	Treatment.	Acre yield of green forage.
			Pounds.
1	5	Complete fertilizer	55,348
2	4	No treatment	28,483
3	3	Plowed plus complete fertilizer	24,426
4	3	Plowed only	19,487
5	5	Complete fertilizer	39,291
6	3	No treatment	15,887
7	4	Plowed plus barnyard manure	29,344
8	6	Barnyard manure	65,604

The fertilizer used on plats 1, 3, and 5 was applied at the rate of 65.5 pounds of nitrogen, 59.5 pounds of phosphoric acid, and 100 pounds of potash per acre. The nitrogen was furnished by nitrate of soda which was given in four applications, and the phosphoric acid and potash in two applications. Plats 7 and 8 were treated with a single application of barnyard manure at the rate of approximately 15 tons per acre. The effect of each commercial fertilizer application was apparent within five days. The grass on the fertilized plats grew much more quickly and had a larger percentage of stems than that on the unfertilized plats.

The plowing of plats 3, 4, and 7 was done on August 4, 5, and 6. On plats 3 and 4 no cutting was made until December; while on plat 7 a cutting was made in September. The barnyard manure, therefore, brought about a much quicker recovery of the grass than did the commercial fertilizers.

The decidedly beneficial effect of the plowing alone was shown in the April cutting, when plat 4 yielded at the rate of 8,913 pounds of green forage per acre, while plat 3 adjoining, although fertilized and plowed, gave only 10,869 pounds per acre. Counts made in May showed that the stand on plat 4 had been slightly more than doubled, as compared with unplowed and unfertilized plat 6. The commercial fertilizers have brought about a slightly increased stand. Yields during the next fiscal year should be of particular value in these comparisons. At present plats 7 and 8 have the best stands.

For thickening up a stand of Para grass, barnyard manure containing the residues from Para-fed stock appears to be particularly effective. Careful spreading of the manure is absolutely necessary. A medium application, say 15 tons per acre, made near the beginning of the wet season, appears to be sufficient at one time.

On the untreated plats, the stand has continued to decrease and native grasses and weeds are rapidly taking the place of the Para.

Methods of planting.—Until this past year, Para grass roots have been planted some 3 to 5 feet apart in rows about 3 or 4 feet apart. This method has been expensive, digging and planting the roots, exclusive of plowing, costing about $10 per acre. This is not the only drawback. At least four months are required for grass planted near the beginning of the rainy season to make sufficient growth either for soiling or for pasture uses. During the early part of August, 1915, about one-half acre of Para grass was planted by the old method, and not until December 15 had the grass grown sufficiently for hogs to be turned in to pasture.

Observation on the quick growth of refuse pieces of Para, mixed with manure from the barns, led to a trial of planting the grass stems. A field of 1 acre was carefully plowed during the latter part of October. Furrows were laid off about 3 feet apart and on November 5 a mowing

of Para grass was scattered rather thickly in the furrows and covered with dirt which was slightly packed down. The cost of planting the acre, not including plowing, was $3.60. Within one week growth had started at the joints of the stems, and in two weeks the rows were plainly marked by new shoots. At the end of six weeks the grass had well covered the ground and reached an average height of 3 feet (Pl. IV, fig. 1).

A second trial with this method of planting was made April 27, and a third on May 9. Planting was done on rainy days, but in each case some 10 days of dry weather immediately followed. Yet in those intervals the grass sent up its shoots. Successful results from planting roots without irrigation would have been impossible under such weather conditions. The new method, therefore, is especially desirable, as it permits planting before the regular rains start and thereby provides pasture or a soiling crop during the rainy season. This method is of great importance when considering the extension of the grass on a farm. With such yields as were obtained the past year on fertilized plat 1, the grass produced from 1 acre would plant approximately 25 acres.

Use as pasture and soiling crop.—Most satisfactory results have been obtained from using Para grass as a pasture crop for hogs. It is certainly Guam's best crop for that use. As a soiling crop for feeding to stabled horses, the results have not been so satisfactory, but when used along with other roughage it fills an important place. Detailed results of its use for pasture and for soiling will be found in the report of the veterinarian and animal husbandman (see p. 52).

PASPALUM DILATATUM.

While the adaptability of *Paspalum dilatatum* to soil conditions has been shown to be considerably wider than that of any other grass which this station has tested, yet the past two years have served somewhat to show the limitation of its successful growth. Early this fiscal year plantings were again made. The data from these tests, together with those from former plantings, admit of the following conclusions to date regarding the adaptability and the planting of this grass:

One and one-half acres of *Paspalum dilatatum*, planted in August, 1914, on high land where outcrops of rock and cascajo are common, kept two young bulls in excellent condition during the first six months of this fiscal year. While the grass grew well up to February 1, from then until near the end of the year it afforded little pasturage. Another acre and a half on lowland afforded sufficient pasture for three mature animals until March 1. It would appear that during the rainy season *Paspalum dilatatum* on relatively high land has a value of fully one-half that planted on lowland.

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Tests have clearly shown that *Paspalum dilatatum* on higher lands should be planted thickly (the distance left between the divided roots to be no more than 18 inches each way), and that large divisions of the roots should be used. About one-half acre of shallow cascajo soil on high ground near the station residence, where divisions of sod 3 inches square were placed about 18 inches apart, was well covered in four months (Pl. IV, fig. 2), while grass planted in one of the goat pastures in even better soil, with small root divisions some 30 inches apart, has not covered the ground so well 11 months after planting. On the lower lands smaller divisions and a greater distance of planting may be used. One acre on which the roots were planted in rows some 5 feet apart in September, 1914, is at this time quite well covered. The grass in these latter tests has been used very little for pasture. In any case it seems advisable even on lowland to use large divisions of roots in planting and to set them not more than 2 feet apart each way, if the grass is expected to form sufficient turf to make valuable pasture in a reasonable time.

Careful preparation of the soil before planting is desirable. About one acre of *Paspalum dilatatum* was planted in August, 1915, on land that had been cleared but not plowed or otherwise prepared. The grass started quickly, but at the end of nine months it had made almost no headway and will probably be crowded out ultimately by native grasses and weeds. The soils at the station are generally so heavy that deep preparation is required for proper grass root development. Another acre of grass planted on similar but well plowed and worked soil covered the land well in four months.

Careful attention after planting is neccessary. Even in land well cleared and well prepared, particularly on the higher and poorer soils, weeds must be kept down after planting. All of the soils here are literally filled with weed seeds, and at least three weedings are necessary on poor soils. This is well shown on approximately one acre of grass planted with small divisions set about $2\frac{1}{2}$ feet apart in August, 1915. About two-thirds of this planting was cleaned of weeds three times during the year, while the remainder was given no attention. At the end of nine months the grass had covered fully two-thirds of the soil where weeds were removed, while almost no growth was made on the unweeded part of the plat. Thick plantings and the use of large root divisions on lowlands largely obviate the necessity for weeding, but on carefully planted higher lands weeding is necessary.

Live stock should not be pastured on the grass until four months after planting under ideal conditions. At this station pasturing too soon has destroyed two plantings. On higher lands fully six months should be allowed for the grass to become established.

FIG. 1.—PIGEON PEAS AS TEMPORARY WINDBREAK.

FIG. 2.—JACK BEANS 125 DAYS AFTER PLANTING.

FIG. 1.—PARA GRASS SIX WEEKS AFTER PLANTING CUTTINGS OF STEMS.

FIG 2.—PASPALUM DILATATUM 15 MONTHS AFTER PLANTING ON HIGH CASCAJO SOIL.

GUINEA GRASS (*Panicum maximum*).

Unsatisfactory results have been obtained with Guinea grass at this station. Five and one-half feet has been the maximum height obtained on the most friable and best drained soil during the past two years. A planting was made in August, 1914, on side-hill land, and while the grass made a satisfactory start a year later none of it remained in the field. It is far inferior when compared with Para grass for soiling purposes. In the southern part of the island, where the soils are more open, and consequently better drained, far better results have been secured with Guinea grass than at this station.

MILLET.

On December 31 a planting was made of Hungarian, German, and Pearl millets. None of the German millet seed grew, and the stands on the other plats were poor. On April 11 the average height of Hungarian millet plants was 13 inches, with heads 1 inch long, and of Pearl millet plants 3 feet 2 inches, with heads 3½ inches long. This test tends to show the inadvisability of endeavoring to grow either of these in Guam.

ELEPHANTORRHIZA ELEPHANTINA.

Roots of this shrubby leguminous plant were introduced in May, 1915, and planted immediately. While some growth has been made, yet the plants have done poorly. Conditions in Guam do not appear to be at all suitable to its growth.

RUSSIAN SUNFLOWER.

Two crops of Russian sunflowers were grown. The following table shows the results obtained from plats approximately one-twentieth of an acre in size:

Yield of Russian sunflower seed.

Date of planting.	Treatment.	Date of harvesting.	Yield of seed per acre.
			Pounds.
Dec. 2	Unfertilized	Apr. 16	1,435
Jan. 7	Fertilized	May 2	1,397
Do	Unfertilized	...do...	1,597

The fertilizer treatment was at the rate of 320 pounds of acid phosphate, 320 pounds of nitrate of soda, and 120 pounds of sulphate of potash. The plat had been fertilized for tobacco but was not planted to that crop. Many of the sunflower heads measured 10 inches in diameter. It would appear desirable for a small area of this crop to be grown for use in compounding rations for poultry.

HORTICULTURAL INVESTIGATIONS.

SEED AND PLANT INTRODUCTION.

In October a shipment of citrus trees, including orange, grapefruit, and lemon, was received from California. All of the trees came through in excellent condition. A shipment of 22 trees of 11 tropical species was received from the Office of Foreign Seed and Plant Introduction, of this department, in March. Of the latter, the only successful introductions were 3 plants of the Queensland nut (*Macadamia ternifolia*); 2 plants of cherimola (*Annona cherimola*); 3 plants of *Eugenia luschnathiana;* and 1 plant of *Cudrania javanensis* (hedge plant).

The most important seeds introduced included varieties of *Holcus sorghum*, *Beta vulgaris*, *Brassica pekinensis*, *Capsicum annuum*, *Cucurbita pepo*, and *Lactuca sativa*.

SEED AND PLANT DISTRIBUTION.

Plants.—The total number of fruit and ornamental trees distributed over the island during the year exceeded 33,450. This was a large increase over any preceding year. The following list gives the names of the plants distributed: Fruits, *Carissa arduina*, papaya (*Carica papaya*), avocado (*Persea gratissima*), mango (*Mangifera indica*), pineapple, banana, and cacao; ornamentals, *Barleria cristata*, *Cestrum nocturnum*, *Gardenia jasminoides*, *Tabernæmontana grandiflora*, *Graptophyllum pictum*, *Odontanema nitidum*, *Schinus* sp., *Gardenia* sp., and *Hibiscus* sp. About 130 plants of *Pimenta acris* were also distributed.

The demand for plants has far exceeded the available supply. This has been particularly true of the different varieties of hibiscus. At the end of the fiscal year, requests for several thousand plants were on hand. In May, cuttings of ornamental shrubs were made and these will be ready for distribution as soon as the rainy season, the favorable planting time, sets in.

The demand for grass roots also showed a substantial gain. Some 725 sacks of Para, paspalum, and Bermuda grass roots were placed in different parts of the island.

Seeds.—The garden seed distribution has been continued, although the amount has been slightly curtailed in order to determine whether the natives are sufficiently interested to grow their own seeds. Observations in this particular have been encouraging, and it is said by men who frequently travel over the island that more vegetables are being grown than for several years. The station has cooperated with the department of education of the naval government of Guam by furnishing seeds for gardens maintained by all the schools on the island.

The same classes and varieties of vegetable seeds were distributed as during the fiscal year 1915. In addition to the garden seeds, seed of the following field crops were distributed: Kafir, milo, feterita, cowpeas, velvet beans, and tobacco.

VEGETABLE GARDENING.

During the year, the work in vegetable gardening has been placed upon an experimental basis. Plantings have been made every two or three weeks throughout the year when possible. At times, particularly during the rainy season, planting had to be delayed owing to excessive wetness of the heavy clay soils in the station's garden plats.

On the fertilized plats of beans, carrots, peppers, eggplants, okra, radishes, and other vegetables tested, a complete fertilizer containing 85 pounds of nitrogen, 149 pounds of phosphoric acid, and 200 pounds of potash per ton was applied broadcast at the rate of 1,000 pounds per acre, and then worked well into the soil previous to planting. Watermelons, muskmelons, squashes, pumpkins, and cucumbers have been fertilized and planted as follows: Holes approximately 6 inches square and 5 inches in depth were dug the required distances apart, depending upon the vegetable; about one-fifth of a shovelful of rotted manure placed in the bottom, 2 inches of dirt thrown in, and the manure and dirt compacted; approximately one-fourth pound of nitrate of soda, one-fourth pound of acid phosphate, and one-eighth pound of muriate of potash placed in the hole and well mixed with the soil; the hole then filled, being compacted as filled, and the seeds planted about one-half inch below the surface. About one month after planting, nitrate of soda, dissolved in water at the rate of 2 teaspoonfuls to 3 gallons of water, was given at the rate of about one-half gallon of solution per hill. A second application was given about two weeks later in all cases.

In the fertilizer tests the aim during this year has been primarily to determine the general effects of fertilizers. Since the need of fertilization has been shown in almost all tests, during the coming year it is planned to seek more specific information on the effects of different fertilizer combinations, top-dressings, etc., on the most important vegetable crops.

Unfertilized plats alongside fertilized plats have been used in almost every case, and where the land available has permitted, duplicate fertilized and unfertilized plats have been used. Unless otherwise stated, the yield of each vegetable noted in the following pages is based upon plats of one-fiftieth of an acre in size. Yields have not been obtained, except in the case of radishes, from the plantings made after April 15.

The side-hill garden mentioned in the last annual report largely failed. The past rainy season was relatively dry. Vegetables planted in the side-hill garden suffered frequently from lack of water and were far inferior to those produced in the lowland garden.

Beans.—Pole beans: The variety of pole beans known as Kentucky Wonder, distributed over the island by this station during the past two years, was used in the work (Pl. V, fig. 1). The following data are available on the 15 plantings completed during the year:

Effect of fertilizers and time of planting on yield of beans.

Planting No.	Date of planting.	Date of first picking.	Date of last picking.	Yield.	
				Fertilized plat.	Unfertilized plat
				Pounds.	*Pounds.*
1	May 17	Aug. 4	Sept. 18	82.25	(1)
2	Aug. 6	Oct. 2	Oct. 30	104.50	69.0
3	Sept. 3	Oct. 9	Dec. 23	151.00	82.5
4	Sept. 20	Nov. 10	Dec. 14	122.50	70.0
5	Oct. 7	Dec. 4	Dec. 20	95.00	69.0
6	Oct. 27	Dec. 20	Jan. 28	153.00	125.0
7	Nov. 17	Jan. 10	Feb. 7	86.50	44.0
8	Dec. 2	Jan. 22	Mar. 10	22.00	5.5
9	Dec. 27	Feb. 29	Mar. 20	36.00	29.0
10	Jan. 14	Mar. 4	Mar. 27	27.00	25.5
11	Feb. 1	Mar. 17	Apr. 7	30.00	17.0
12	Feb. 16	Apr. 14	May 11	38.25	24.0
13	Mar. 13	May 3	May 26	55.00	37.5
14	Apr. 1	June 6	June 23	53.50	46.0
15	Apr. 15	June 9	June 26	51.00	25.0

[1] No test.

During the driest season (from Feb. 1 to Apr. 15) and in periods following high winds the beans produced were decidedly inferior. Most of the pods were distorted, tough, and only partly filled. During the remainder of the year the beans were excellent.

Conditions were favorable during the entire growth of plantings Nos. 1, 2, 3, 4, 5, and 6. Planting No. 7 was badly injured and No. 8 practically ruined by high, dry winds from December 30 to January 16. Although irrigations were given during dry periods, the hot, dry weather caused low yields from plantings Nos. 9, 10, 11, and 12.

The native ranchers are particularly partial to the Kentucky Wonder bean because of its ease of growth, prolificacy, and long period of production.

Wax beans: Previously this station has had good success with the variety of wax string beans known as the Pencil Pod Black Wax. It appears, therefore, to be extraordinary that this variety of beans proved almost a total failure during this year. The only plantings that gave yields of more than 5 pounds per one-fiftieth acre were those made September 20 and October 7 and 27. From some of the fertilized plantings the quality of the beans was fair. From all other plantings the beans have been uniformly small, tough, and distorted. The vines grew well in all cases.

In the Naval Station garden, at Agana, the results with this variety have been as disappointing during this year as those obtained at the station.

Lima beans: Eighteen plantings of Henderson's Dwarf Bush lima bean were made during the year. Data are available upon only 13 plantings. The following table gives the principal data obtained:

Effect of fertilizers and time of planting on yield of lima beans.

Planting No.	Date of planting.	Date of first picking.	Date of last picking.	Yield.	
				Fertilized plat.	Unfertilized plat.
				Pounds.	*Pounds.*
1	June 7	Aug. 23	Dec. 11	(1)	61.0
2	Aug. 6	Oct. 13	Nov. 30	32.0	20.0
3	Sept. 3	Nov. 2	May 11	167.0	127.0
4	Oct. 7	Dec. 11	...do....	173.0	129.0
5	Oct. 27	Jan. 3	June 26	106.5	84.0
6	Nov. 17	Jan. 17	Apr. 25	124.0	100.5
7	Dec. 2	Feb. 1	May 2	99.0	75.0
8	Dec. 27	Mar. 17	May 11	177.0	26.5
9	Jan. 14	Mar. 21	(2)	84.5	63.0
10	Feb. 1	Apr. 4	(2)	61.0	45.0
11	Feb. 16	May 11	(2)	36.5	19.5
12	Mar. 13	June 9	(2)	37.0	17.0
13	Apr. 1	June 13	(2)	23.5	10.0

[1] No test. [2] Still producing at this date (June 30) and records therefore not complete.

The beans produced from all plantings were sweet and tender. The number of crops produced from a planting varied somewhat with the season, but three distinct crops was an average. The period of production for each crop varied from one to three weeks, with an average of about 10 days. During dry periods in the rainy season a crop would set on. Notes of the bean production are practical records of the rainless periods.

Insect enemies gave little trouble. Plantings made during the rainy season were generally somewhat attacked by a leaf miner, and in cases of delayed harvesting the beans were often partly destroyed by a moth larva.

Variety test of string beans: A test embracing 10 varieties of bush string beans was started on December 2. All plats were fertilized in the regular manner. Seed of four varieties failed to grow. The principal data obtained are given in the following summary table:

Variety test of string beans.

Variety.	Date of first picking.	Date of last picking.	Yield per plat.
			Pounds.
Refugee	Jan. 16	Feb. 6	47.5
Black Valentine	Jan. 18	Feb. 1	41.0
Yellow Six Weeks	Jan. 14	Jan. 28	34.5
Kidney Wax	Jan. 15	Feb. 6	27.5
Pencil Pod Wax	Jan. 18	Mar. 24	10.0

Aside from the varieties noted above, that known as Scarlet Runner was included in the test. This latter flowered profusely and set pods, but when these had grown to about one-half inch in length, they withered and dropped from the vines. The high winds from December 30 to January 16 may have caused the failure to mature fruit.

Peppers.—Results were obtained from eight plantings of the Ruby King variety of peppers. Tests 7 and 8 were made particularly to determine the effect of shading during the dry season upon production and pungency of peppers, and these will be considered under the heading, Shading. The summarized data on the first six tests are given in the following table:

Effect of fertilizers and time of planting on yield of peppers.

Planting No.	Date of planting.	Time of picking.	Fertilized plat.		Unfertilized plat.	
			Number of pods.	Weight of pods.	Number of pods.	Weight of pods.
				Pounds.		*Pounds.*
1	June 7	Aug. 5 to Apr. 11	4,220	341	(1)	(1)
2	Aug. 2	Oct. 11 to Apr. 11	5,316	424	2,476	197
3	Sept. 3	Nov. 2 to June 30 [2]	4,712	407	3,692	278
4	Oct. 27	Dec. 21 to June 30 [2]	2,864	249	2,008	155
5	Nov. 17	Jan. 18 to June 30 [2]	1,208	88	716	51
6	Dec. 2	Feb. 11 to June 30 [2]	2,284	183	936	66

[1] No test. [2] Still producing, and records, therefore, not complete.

The size and quality of the peppers varied with the season and the age of the plants. It was uniformly true that the earlier peppers were the largest, sweetest, and crispest. Peppers picked on October 11 averaged 7 to the pound, whereas those from February pickings averaged 26 to the pound. With plantings made during the early part of the wet season, the excellent quality and large size continued for three months after planting. During all seasons, with an occasional exception, the peppers were sweet and of excellent flavor.

Hot, dry weather was the only enemy of the peppers this year. On unshaded plats in dry weather, watering, largely offset by the hot sun, only slightly improved the quality of the peppers. Peppers produced on fertilized plats were uniformly larger and of better quality.

Shading: Two plantings were made in this test to determine the effect of shading upon pungency and growth of peppers in the dry season. The variety of sweet peppers known as Ruby King was used in both plantings and the results obtained are as follows:

Effect of shading on yield of peppers.

Test.	Treatment.	Date of planting.	Date of first picking.	Stand.	Height of plants at first picking.	Yield.[1]	
						Number of pods.	Weight of pods.
				Per cent.	*Inches.*		*Pounds.*
1.....	Fertilized, shaded.....	Jan. 14	Mar. 28	94	21.0	1,340	171
1.....	Fertilized, unshaded.....	...do.....	...do.....	78	13.0	752	60
2.....	Fertilized, shaded.....	Mar. 13	May 27	94	19.0	376	47
2.....	Fertilized, unshaded.....	...do.....	June 6	21	14.5	66	7
2.....	Unfertilized, shaded.....	...do.....	June 9	89	13.5	112	14
2.....	Unfertilized, unshaded.....	...do.....	June 22	24	11.0	32	3

[1] All plantings still producing at the end of the year (June 30).

Healthy plants some 4 inches high were used in both tests. The peppers were transplanted on rainy days, under ideal conditions, but more than three fourths of the unshaded peppers in the second test were dead in two weeks.

The test revealed only one lot of pungent peppers, produced on the shaded plat of the January 14 planting. No other pungent peppers have been noted on any plat.

The successful transplanting of peppers in the dry season is exceptionally difficult where no shade is used. Shading largely counteracts the effects of hot weather and makes good stands possible with the use of about half the irrigation water necessary on unshaded plats. Shading also increases the size of plants and produces peppers with thicker, crisper flesh.

Eggplants.—Seven crops were produced during the year. Seed was planted in flats and the plants transferred to garden plats when approximately 4 inches high. The yields and the average weight of individual fruits were greatest for the fertilized plats, but the data are too meager for definite conclusions. Few fruits were set in the rainy season, and those which were seldom grew larger than a hen's egg before rotting.

The planting which started to fruit on December 6 was the first that could be classed as successful for the year. Dry, hot days were frequent during the fruiting of plantings made between November 17 and January 18, but the plants did not appear to be injured to any considerable extent. The first fruits were invariably larger than those produced later, and often individual eggplants were secured which weighed $2\frac{3}{4}$ pounds from the fertilized and $2\frac{1}{4}$ pounds from the unfertilized plats (Pl. V, fig. 2). The eggplants produced this year were uniformly of excellent flavor and texture. Those produced during the latter part of the long dry season of 1915 were coarse and somewhat bitter.

The successful transplanting of eggplants proved to be much easier than the transplanting of peppers or lettuce. While it was difficult

even with heavy irrigation to transplant peppers successfuly during the dry, hot weather, few eggplants were lost.

Radishes.—Two varieties, namely, Cincinnati Market and Early Scarlet Turnip, were used in the tests the past year, and records were obtained from 16 plantings. The highest production, 224 pounds of marketable radishes, was obtained from a planting of Cincinnati Market made on September 3 and harvested from October 13 to November 30. The lowest yield from plats not attacked by the cabbage webworm (*Hellula undalis*) was 80 pounds from a planting made on December 2 and harvested from January 18 to February 14. The time required for the radishes to reach an edible size varied from 25 days with the planting made July 2 to 42 days with the planting made September 27. Growth was uniformly slower during the rainy season than during the dry season.

The cabbage worm proved especially injurious to plantings made during the dry weather. It completely destroyed every planting made from December 27 to April 1. During the rainy season no apparent damage on fertilized plats was done by the insect, although it ruined the radishes on the unfertilized plats of the September 27 planting, and badly injured the August 6 and October 27 plantings. Spraying with lead arsenate against this insect proved effective only on fertilized plats. In the Naval Station garden, at Agana, fair success has followed the use of a lead arsenate during the rainy season on unfertilized plats.

The effect of fertilizers was more marked on radishes than on any other garden crop. Aside from helping to overcome the cabbage worm (*Hellula undalis*), it gave an average increase of 225 per cent in the crop. Unfertilized Cincinnati Market radishes yielded 60 pounds, while fertilized ones gave 224 pounds.

The Cincinnati Market yielded approximately one-third more radishes per plat than the early Scarlet Turnip.

Carrots.—The past year served to show the extreme hardiness of the carrot in all months. The Oxheart variety was used in the four tests upon which data are available. The following table gives the yields obtained:

Effect of fertilizers and date of planting on yield of carrots.

Planting No.	Date of planting.	Time of picking.	Yield.	
			Fertilized plat.	Unfertilized plat.
			Pounds.	*Pounds.*
1	July 2	Sept. 21 to Jan. 8	104.0	(1)
2	Aug. 6	Dec. 4 to Apr. 5	172.5	96
3	Oct. 7	Jan. 8 to June 26	218.0	120
4	Oct. 27	Feb. 15 to June 24	239.5	94

[1] No test.

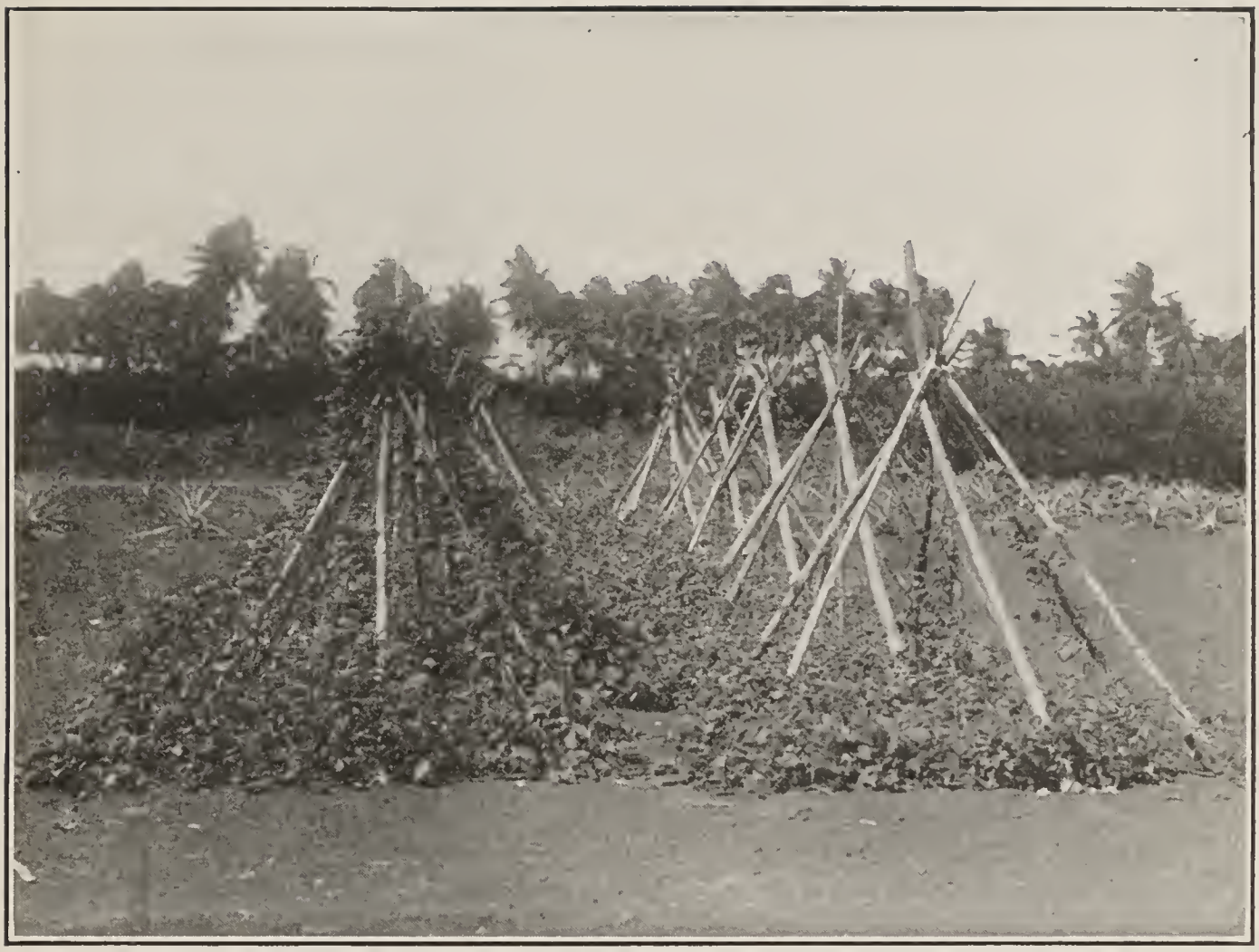

FIG. 1.—FERTILIZED AND UNFERTILIZED KENTUCKY WONDER BEANS.

FIG. 2.—SIXTH PLANTING OF EGGPLANTS.

Photographed April 10, 1916

FIG. 1.—INARCHED MANGO TREE 22 MONTHS AFTER PLANTING.

FIG. 2.—A HIGH-YIELDING PAPAYA.

The quality of the carrots has been in every case excellent, the expressed opinion of American residents of Guam indicating that Guam-grown carrots are as sweet and as tender as it is possible to produce. Many of the carrots harvested weighed one-third of a pound each. These were as sweet and as tender as smaller ones. During the driest season, from February 1 to April 15, it was difficult to obtain good stands. As has been noted, the soil in the station garden is heavy. With slow germinating seeds like those of carrots, it is difficult to keep such soil uniformly moist on extremely hot, dry days. Plantings started readily at all other times during the year.

Muskmelons.—The first planting of muskmelons was made on June 7, 1915, and consisted of seed of 27 varieties, received on May 28 from the Office of Foreign Seed and Plant Introduction, of this department, together with seed of Extra Early Hackensack, Netted Gem, and Burrell's Gem. The results of this test were unsatisfactory, the only varieties maturing melons being the Extra Early Hackensack, the Burrell's Gem, and S. P. I. Nos. 30642, 30469, and 30640.

To heavy rains during the latter stages of growth may be traced the failure to ripen fruit in 25 of the 30 varieties included in the test. Fruit set on every variety tested. S. P. I. Nos. 30642 and 30469 produced fruit of inferior quality, and no seed was saved from the melons that ripened. No. 30640 had melons of exceptionally fine flavor and texture.

During the rainy season an effort was made to prevent rotting of the growing melons by placing bamboo poles under the vines and keeping the melons off the ground. The melons were turned every two days. The scheme promised good results, but rats and land crabs proved destructive, most of the melons being destroyed before they were sufficiently matured to be picked.

Plantings of all the above varieties were made on December 3, and replantings on December 11, but no stand was obtained of any variety except Burrell's Gem, of which fresh seed was used.

Ten other plantings of Burrell's Gem and three of Rocky Ford Gold Lined were made during the year. All those made between August 2 and December 27, inclusive, were failures, only an occasional melon maturing. The earliest planting proving at all successful was made on January 14, on which an average of two melons per plant was obtained. Fair success attended plantings made on February 1 and 15, March 13, and April 1. The crops were so generally poor that no effort was made to keep records of production. Little difficulty was experienced in obtaining stands, and except during periods of high winds the growth of vines was all that could have been desired. The melons generally were of excellent flavor and texture. The results this year place muskmelons in the list of possible vegetable crops for Guam.

Cucumbers.—The Fordhook Famous variety was used in all general trials during this year. A summary of the results obtained is given in the following table:

Effect of fertilizers and date of planting on yield of cucumbers.

Planting No.	Date of planting.	Date of first picking.	Date of last picking.	Yield.	
				Fertilized plat.	Unfertilized plat.
				Dozen.	*Dozen.*
1	June 8	Aug. 4	Sept. 16	88¾	(1)
2	Aug. 7	Sept. 22	Oct. 15	89½	(1)
3	Aug. 28	Oct. 13	Nov. 30	64	(1)
4	Sept. 18	Nov. 27	Jan. 7	21⅛	22⅛
5	Oct. 7	Dec. 4	Jan. 28	55½	23¾
6	Oct. 27	Dec. 23	...do.....	26	8
7	Nov. 17	Dec. 31	...do.....	12	5¼
8	Dec. 2	Jan. 18	Mar. 28	48	31
9	Dec. 27	Feb. 25	Apr. 11	12	9
10	Jan. 14	Mar. 3	...do.....	16	5
11	Feb. 1	Mar. 4	Apr. 28	10½	6
12	Feb. 16	May 8	June 14	21	8
13	Mar. 13	May 15	...do.....	10	8
14	Apr. 1	May 23	(2)	29⅓	22⅝
15	Apr. 15	May 27	(2)	30½	20¾

[1] No test. [2] Plantings numbered 14 and 15 still producing at this date (June 30).

The cucumbers produced from February 1 to May 1 were tough and some 70 per cent of them were distorted; and during the months of October, November, December, and January it was estimated that 55 per cent of them were not marketable. During August, September, May, and June it was estimated that 90 per cent of the cucumbers were marketable. All marketable cucumbers were of excellent quality, being sweet, crisp, and well shaped.

High winds were particularly detrimental to the growth of cucumbers. The winds of October 23 to 25, inclusive, badly injured plantings Nos. 4 and 5, and those from December 30 to January 16 practically ruined plantings Nos. 6 and 7 and injured somewhat planting No. 8. Many of the vines were blown from the soil and almost all were injured in the winds from December 30 to January 16. Cucumbers in Guam should be protected on all sides from winds.

During the most rainy season (from September 1 to November 1) the leaves of all plants were often badly attacked by aphids. Slight success attended throwing a solid stream of water on the underside of the leaves.

Shading proved detrimental to the growth of cucumbers during the dry season. The vigor of the shaded plants was reduced and fully one-third died, although regularly watered.

A plat of Japanese climbing cucumbers was planted on October 27. One light picking of excellent cucumbers was obtained after which the plants died.

Watermelons.—Ten plantings of the Tom Watson were made and practically the only melons obtained were from the June 8, December

2, January 14, February 1 and 16, and March 13 plantings. The December and January plantings averaged four melons of excellent quality per hill.

The tests this year indicate that watermelons should be planted so as to fruit from April to August, the earlier date giving the best results. During the rainy season an excellent growth of vines was uniformly obtained, but most of the melons that set on the vines rotted before reaching the size of baseballs.

From a planting made on June 8 of 13 varieties, including seed of 8 obtained from the Office of Foreign Seed and Plant Introduction, of this department (S. P. I. Nos. 27986, 27858, 32245, and 32244), there were produced fruits of good quality, but none equaled those produced by the Tom Watson variety.

Squash.—The variety known as Mammoth White Bush Scallop was grown throughout the year with more or less negative results. During every period of a few dry days fruit set and developed, while the squashes which set on rainy days invariably rotted on the vines before reaching one-fifth their normal size. Planting during the wet season proved to be only a speculation.

Plantings from December 27 to May 8 gave fair yields. The highest yield, six squashes per plant, was obtained from a planting made January 14. Irrigation during the dry season was not successful, the hot sun counteracting its effects. The use of fertilizers increased the yield about 50 per cent. The average time required for the production of mature fruit was 42 days.

Okra.—Okra proved to be hardy and productive. All of the six plantings which had reached the fruiting stage are still producing.

The planting made July 2 is now giving its third crop. The first crop, produced from September 14 to November 2, yielded 154½ pounds; the second crop, from November 27 to April 15, 412½ pounds; and the third crop, from May 5 to June 30, 72 pounds. Yields from the other plantings compare favorably with those from the July 2 planting. The yield from fertilized plats to date is approximately 30 per cent greater than from unfertilized plats. An average of 58 days was required to produce fruit. The first ratoon crop has invariably been larger than the first regular crop, the plants producing more branches.

The natives are learning to appreciate okra. They cook it in combination with rice.

Pumpkins.—Pumpkins were generally unsuccessful during the year. An occasional pumpkin was produced from plantings made from August 2 to November 1. November and December plantings gave fair yields. Records of production were not kept.

Sweet corn.—Two plantings, one on December 1 and the other on December 31, were made of Country Gentleman, Stowell's Evergreen,

and Golden Bantam. A good stand was obtained of all varieties from both plantings, but within one month thereafter all of the plants had died, probably because of the hot sun and heavy winds.

Onions.—A planting of sets was made on a two-hundredth-acre plat on October 31. Onions harvested in December weighed at the rate of six to the pound, while on March 27, when the stems had commenced to fall over and the crop was harvested, the onions weighed at the rate of four to the pound. The total production from the plat was 79 pounds. No insect enemies were noted.

Udo (*Aralia cordata*).—Roots of this highly prized Japanese vegetable were received in May, 1915, from the Office of Foreign Seed and Plant Introduction, of this department. The roots were temporarily planted in the shaded propagating shed, where they made a good start. In August they were planted in the regular garden. A few coarse shoots have been produced, but no effort has been made to blanch them.

Longevity of vegetable seeds.—Vegetable seeds rapidly lose their vitality in Guam, but as there are no specific data available on the subject a test was started on August 1 to determine the longevity of certain seeds when stored in ground glass top exhibition jars and when placed in cloth sacks in insect-proof wooden cabinet drawers. Seeds were obtained from a San Francisco firm, and the first test indicated that all were fresh. Original and duplicate sets each of 100 seeds were used in all tests, except those of beans, where 40 seeds were used in each set. The plate and blotter method of germinating the seeds was employed. Care was exercised to include large as well as small seeds in every set. The following table gives the results obtained up to and including the June 15 test:

Comparative percentages of germination of vegetable seeds stored in jars and sacks.

Date of test.	Carrot.		Pepper.		Water-melon.		Cucum-ber.		Okra.		Radish.		Wax beans.		Lima beans.	
	Jars.	Sacks.	Jars.	Sacks.	Jars.	Sacks.	Jars.	Sacks.	Jars.	Sacks.	Jars.	Sacks.	Jars.	Sacks.	Jars.	Sacks.
Aug. 1	57	60	70	63	74	71	95	94	83	95	100	100	100	100	100	100
Sept. 1	57	41	52	57	77	81	96	93	91	92	94	94	98	98	98	98
Sept. 15	47	31	39	44	77	82	91	96	80	79	94	93	98	88	98	98
Oct. 1	46	34	34	21	85	81	94	94	80	80	95	95	98	90	98	95
Oct. 15	46	32	38	36	84	63	88	78	87	73	93	90	93	80	98	98
Nov. 1	51	19	15	8	64	70	92	91	92	90	95	93	98	88	98	95
Nov. 15	33	7	27	4	78	60	92	63	83	71	93	93	98	45	100	88
Dec. 1	32	10	27	12	57	62	86	54	84	71	89	73	95	0	98	75
Dec. 15	38	0	20	0	55	57	71	19	87	60	95	70	95	0	98	78
Jan. 1	31	0	16	0	38	32	81	17	84	46	86	47	68	0	98	55
Jan. 15	16	0	15	0	39	26	66	36	74	22	87	35	83	(1)	98	48
Feb. 1	27	(1)	18	(1)	41	30	66	8	79	45	82	25	80	....	93	28
Feb. 15	36	....	17	....	55	34	57	2	70	18	89	30	75	....	95	8
Mar. 1	19	....	12	....	32	26	54	4	74	22	88	17	88	....	95	0
Mar. 15	21	....	0	....	38	25	39	0	72	24	90	19	70	....	93	0
Apr. 1	11	....	3	....	38	26	54	5	74	2	86	17	60	....	93	0
Apr. 15	6	....	0	....	55	39	43	0	76	26	94	27	75	....	85	(1)
May 1	19	....	0	....	32	7	23	0	59	22	91	23	53	....	85	....
May 15	25	....	0	....	36	15	18	0	80	17	76	0	38	....	90	....
June 1	8	....	(1)	....	25	6	12	(1)	65	0	68	0	53	....	88	....
June 15	0	....	....	....	36	2	8	....	58	0	47	0	30	....	75	....

[1] Testing discontinued.

ORCHARD NOTES.

It was noted in the last annual report that a new orchard had been laid out. The orchard has been planted principally to tropical fruit trees introduced during 1915 and 1916. All of the citrus plants have made very satisfactory growth. The jujubes (*Ziziphus jujuba*) have practically ceased growing, though a few branches have remained green. The same may be said of the Van Deman pecan trees. The trees of the Spanish lime (*Melicocca bijuga*), Barbados cherry (*Malphigia glabra*), and *Myrciaria cauliflora*, with one Chinese wood-oil tree (*Aleurites fordii*), have made exceedingly good growth. The remaining trees were not planted out until near the end of the fiscal year.

Of the fruit trees introduced previous to July 1, 1914, when the writer took charge of this station, all had been lost except 6 peaches, 4 *Aberia gardnerii*, 6 *Carissa arduina*, 4 kumquats (*Citrus japonica*), 1 persimmon, and the plants of the Spanish lime and the Barbados cherry above referred to. The peaches have developed a bush-like growth and have never borne fruit; the one *Aberia gardnerii* that has borne fruit has given during the past two years eight fair crops, the *Carissa arduina* have given two very light crops, and the kumquats have borne fruit continuously.

On the above date there were also growing several trees of grapefruit, orange, and lemon, but these were so badly diseased that almost all were destroyed during the fiscal year 1915. The trees remaining have given a few fruits of inferior quality.

Mango propagation.—In the mango propagation studies this year (Pl. VI, fig. 1) 18 per cent of the plants were lost in the inarching propagation.

The native, or carabao, mangoes (*Mangifera indica*) of Guam are scant bearers. On the station farm there are seven large trees which have borne during the past two years not more than 200 fruits. One tree has a few fruits on it at the present time. Fertilization is being resorted to in an endeavor to increase production.

Seedlings of the so-called Saipan mango (*M. odorata*) have made about double the growth of either the seedlings or the inarched carabao mangoes during the past 22 months. Inarched plants are especially slow growing and none of those planted in permanent locations at this station have ever fruited.

Pineapples.—An attempt was made this year to increase, by providing good drainage, the number and size of the fruit produced in the station lowland pineapple field. The improvement was even greater than had been expected, many of the fruits produced on the newly drained land weighing 7½ pounds each, with none under 4 pounds. On undrained land none exceeded 4 pounds in weight.

The work at this station, as well as that of painstaking growers here, shows that lowland soil is preferable for growing pineapples if

good drainage is provided, but without such drainage there is little success.

Papayas.—Two plantings of papayas have been made during the past two years, one in November, 1914, and the other in July, 1915. Of the former planting of 30 trees of the so-called "round" type 20 proved to be male plants. Five of the female trees gave fruit inferior in flavor and texture. The 10 trees of a later planting of the so-called "long" type all proved to be females (Pl. VI, fig. 2). The first mature fruit from the first planting was picked on August 1, 1915. The highest yield for one plant to date is 63 fruits, the lowest yield, 16 fruits. The first mature fruit from the second planting was picked on May 19, 1916, being of good quality.

High winds appear to be the only enemy of the papaya, and if it is not grown in a protected location little success will be attained.

Coconuts.—Buyers of copra and coconuts claim that the coconuts produced in Guam are inferior in size and percentage of meat to those grown in many other regions. These men attribute this inferiority to the use of poor or unselected seed, too thick planting, and general lack of cultivation. Since copra forms the only important article of export of Guam, constituting, during the fiscal year 1915, 63 per cent of its total exports, the situation is of no small importance. Under prevailing conditions the native rancher obtains not more than 40 cents per day for his labor in growing and marketing coconuts. It therefore seems advisable to undertake the improvement of the crop by change of cultural methods, by seed selection, or by introducing new varieties. As the natives of Guam seldom cultivate fields if they are occupied only by coconuts, for the present the cultural improvement apparently must be brought about by inducing the natives to grow other crops between the coconut trees. Guam is a relatively small island, and in order to become self-supporting, it must increase its live-stock production. Much of the grass for producing stock could be grown on land now occupied by coconut groves, either by growing the coconuts and grass in combination or by replacing the coconut groves with grass.

Eight plats of 20 coconut trees each were planted as a demonstration to native growers. Two plats are being cultivated and leguminous cover crops will be planted in them during rainy seasons, two plats are devoted to coconuts and Para grass, two plats to coconuts and *Paspalum dilatatum,* and two plats receive no attention. The plants on the first six plats have grown well, while evil effects are already evident on the two neglected plats. Neither distance of planting nor fertilizer tests have been started, as land at Cotot stock farm, where these tests will be conducted, could only recently be cleared. Planting will be done during the coming rainy season.

SUMMARY OF LIVE-STOCK INVESTIGATIONS.

In December, 2 Toggenburg buck goats, 2 Berkshire boars, and 14 cockerels of Brown Leghorn, Barred Plymouth Rock, and Rhode Island Red breeds were received from the States, coming from San Francisco by a schooner which was 43 days en route. This introduction was the first since the original live-stock introduction in November, 1911, and breeding work with hogs and chickens was practically at a standstill except in so far as the effects of inbreeding were studied.

The hog and goat breeding experiments have been placed upon a new basis in order to compare development, disease resistance, etc., of cross-bred animals, containing different percentages of pure blood, and of native animals. In this way a definite idea can be formed of the necessary intensity of pure blood in cross-bred animals. When the new bucks and boars came, the station had 12 sows and 22 does for immediate breeding. As a result, by this date, offspring have been obtained from all sires except one buck goat.

Near the end of the last fiscal year new methods of feeding were installed, and all animals at this station were placed upon definite rations. With the exception of the goat work, the results of all tests have been highly gratifying, and at this time every animal is in excellent condition. Some of the mature horses and cattle have made individual gains of 200 pounds or more.

The use of an arsenical dip for keeping the station cattle free from ticks has been most effective, and the work has not only been far cheaper than the hand picking and occasional use of oils formerly practiced, but it has also resulted in eradicating ticks from most of the pastures. The dip proved most beneficial on the imported Ayrshire cattle, and much of the gain in weight among them was due to their being free of ticks.

All phases of the chicken investigations have been satisfactory. No diseases have appeared among the young chicks except a few cases of diphtheritic roup and chicken pox. New brooding and feeding methods have resulted in reducing by fully two-thirds the mortality of chicks up to 6 weeks of age. Egg production has been greatly increased by proper feeding. With the arrival of the new males, breeding flocks were established, and the offspring of these are being carefully selected. Laying and breeding flocks of all pure-bred and cross-bred chickens will be used during the coming year. The feeding experiment, in which imported and Guam-grown rations are compared for egg production, has resulted in favor of the Guam-grown ration. In this test the pens will be reversed the coming year. Trap nesting has proved successful, and egg records are available for every hen.

With the goats results have been discouraging. From December to June, 14 head of goats under 6 months old and 11 head over 6 months old died due to nodular disease (Œsophagostomum) and the stomach worm (*Hæmonchus contortus*).

This year has gone to prove further the desirability of placing sires for breeding purposes over the island rather than to expect the natives to bring their animals to the station for breeding. The stallion Donald was kept at the Naval Station corral at Agana about 10 months of this year. Four bulls were away from the station during some or all of the year. They were Harry Gray, pure-bred Ayrshire, at Cotot stock farm; John Rhodes, at Merizo; King, jr., at Agana; and Dusty Rhodes, at Yigo. The last three bulls are half-breed Ayrshires. Records of breeding place the number of cows bred at 74 for the year. King, jr., and Dusty Rhodes are young, and a limit of not more than one cow every two weeks was placed upon them. It is planned to place other bulls, and also boars and buck goats, in different localities where dependable stock owners are found.

COOPERATION.

It is gratifying to note that the cooperation between this station and the naval government of Guam has been extended during the year. This cooperation has been felt in various phases of the work, but has been particularly helpful to the people of Guam in the extension of the use of the station sires and in plant distribution. It is largely through such cooperation that the improvement of agriculture on the island can be brought about.

REPORT OF THE FOREMAN OF COTOT STOCK FARM.

By J. Barbour.

Fifteen native cows and three calves have been placed on the Cotot stock farm during the past year and a half, but at this date there are only 24 head of cattle. The Cotot stock farm offers, according to the statements of persons familiar with Guam pastures, as good native pasturage as any to be found on the island. The experience on this farm demonstrates some of the difficulties confronting Guam cattle raisers.

The problem of cattle production is being considered from two standpoints, first, overcoming tick infestation by the use of an arsenical dip, and second, replacing as rapidly as possible the native pasture grasses and underbrush with Para grass (*Panicum barbinode*) and *Paspalum dilatatum*. During this year, the effect of the arsenical dip has been manifested in the generally improved condition of the cows. No deaths have been reported for about nine months. The four calves born at the farm since April 1 are doing well and their condi-

tion may be credited almost entirely to the use of the arsenical dip. Tick infestation of calves is especially detrimental, as those that survive are stunted in their growth.

Some 35 acres of lowland was cleared during the past dry season, but, owing to the almost daily rains, it was impossible to burn the brush on about 15 acres. About 5 acres of Para grass has already been planted, and the remaining 15 acres will be planted during the next two months. This acreage of grass will provide good pasture for the animals now kept at Cotot, and, with the use of the arsenical dip, should result in a substantial increase in the number of animals during the next fiscal year.

Studies of the effects of tick infestation upon native cattle, and of the normal temperatures of cattle and of carabao, are being made at Cotot stock farm. Complete temperature records of six animals are available for the year, but it is deemed best to delay consideration of these until another year's records are obtained. Two cows have been kept tick-free and their temperature records compared with those of two cows infested with ticks throughout the year. The work with these four cows will be reversed the coming year, and at the end of that time, some idea can be formed of the effects of tick infestation upon native cattle.

Plantings of several varieties of fruit trees were made and these will be added to as new supplies are available. Efforts toward obtaining data from vegetable gardening have not been successful because of the destruction by rats of all plantings.

Work with bees has been started and during the next year data will be available upon the weekly honey production of four colonies.

REPORT OF THE VETERINARIAN AND ANIMAL HUSBANDMAN.

By L. B. Barber.

HORSES.

PURE-BRED MORGANS.

Of the four Morgan mares introduced in October, 1911, one met with accidental death in 1913, but the three remaining mares are now in good condition. Princess Angeline (Pl. VII, fig. 1) has foaled two colts, the first in February, 1913, and the other in August, 1914. This mare is showing signs of advanced pregnancy at the present time. Mayport has given birth to only one colt, in November, 1914. From that foaling date until her first period of heat was 190 days. Her next periods of heat were in July and August, but still she did not get with foal. She was bred the last time in November of this fiscal year, but has shown three periods of heat since then. Kit of Willowmoor was bred repeatedly during 1912, 1913, and 1914, but

failed to become pregnant until January 17, 1915, when artificial impregnation was employed. She delivered her foal in December of this fiscal year. The foal became infected with the tetanus bacillus and was lost when 6 days old.

The first Guam-born Morgan colt was Mariana Belle. She is now a little past 3 years old. Her present weight is 795 pounds and she is not pregnant. Since July 1, 1915, this mare has made a gain of 215 pounds. During the first two years, Mariana Belle's growth was checked, doubtless through placing too much reliance upon the feeding value of Para grass for young stock. Mariana Belle had, until this past year, serious infestations of the maw worm (*Oxyuris equi*), which, no doubt, also interfered with her normal development. Even at the present time, after her gratifying gain in weight, she lacks vitality.

Lady Cassius, the second Morgan colt born in Guam, is now almost 22 months old and weighs 495 pounds, while Dixie Cassius, the third colt born at this station, is now 19 months old and weighs 510 pounds (Pl. VII, fig. 2). These fillies have made fairly consistent gains and their condition at the present time is good. Alfalfa hay was made a portion of their forage ration during this year.

CROSS-BRED HORSES.

The average weight of the native horse, based on 15 animals, or one-fourth of the total number on the island, is 460 pounds. These animals are extremely hardy and are able to exist on the native pastures without shelter of any kind. That this hardiness is greatly superior to that of the station's Morgan horses is shown by the fact that the latter have, with only one exception, lost weight when placed in good *Paspalum dilatatum* grass pastures and provided with shelter.

The principal object of the station in the cross-breeding work with horses has been to develop horses with greater size and improved conformation, in other words, serviceable horses, that possess to the largest possible extent the hardiness of the native horses. The results have been encouraging. The only Morgan-native horse 3 years old is kept at Merizo. There are no facilities there for weighing horses, but his weight is estimated to be about 750 pounds. Of 2-year olds, the average weight of two Morgan-native horses is 550 pounds. In style and conformation, the cross-bred horses are such that an observer can readily distinguish them in a native herd, while their hardiness is such that they have been able to develop from birth in the wild pastures without extra feed along with their native mothers.

The extension of the breeding of the two Morgan stallions owned by this station has been difficult but it is believed that the object lessons in the young half-blood horses now on the island will bring

to the natives a realization of the value of the Morgan blood. The plan started about one year ago of placing sires over the island appears to be the only solution of the matter.

A 1,200 or 1,300 pound horse is best for work purposes in Guam, but this size can only come after the present size of the native horse is increased. The use of Morgan blood is necessary in attaining the desired size.

FEEDING EXPERIMENTS.

An experiment to determine the feeding value of Para grass for horses confined in stalls was begun on September 1. Alfalfa hay was used as a check feed. The stallion Cassius and the mare Princess Angeline, both Morgan horses, were used in this test. The horses are of practically the same age and are given the same general treatment. The following table gives the results obtained to June 1:

Results of an experiment in feeding Para grass to horses.

	Daily ration.			Weight.		
	Para grass.	Oats.	Alfalfa hay.	Beginning.	Close.	Gain (+) or loss (−).
CASSIUS.						
First period:	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
Sept. 1 to 24	40	5	.....	865	845	−20
Sept. 24 to Nov. 30	60	5	.....	845	870	+25
Gain for period	.....	.....	.....	.....	.....	5
Second period:						
Dec. 1 to Jan. 24	.....	5	15	870	930	+60
Jan. 24 to Feb. 29	60	5	.....	930	932	+ 2
Gain for period	.....	.....	.....	.....	.....	62
Third period: Mar. 1 to May 31	60	5	.....	932	935	+ 3
Gain for period	.....	.....	.....	.....	.....	3
Total gain	.....	.....	.....	.....	.....	70
PRINCESS ANGELINE.						
First period:						
Sept. 1 to 24	.....	5	10	720	760	+40
Sept. 24 to Nov. 30	.....	5	15	760	835	+75
Gain for period	.....	.....	.....	.....	.....	115
Second period: Dec. 1 to Feb. 29	60	5	.....	835	903	+68
Gain for period	.....	.....	.....	.....	.....	68
Third period: Mar. 1 to May 1	.....	5	15	903	980	+77
Gain for period	.....	.....	.....	.....	.....	77
Total gain	.....	.....	.....	.....	.....	260

Princess Angeline was bred on September 9 and to her pregnancy must be charged some of her gain in weight. She is not due to foal until August 14, 1916. Cassius became suddenly ill on January 24,

and because of his feverish condition, it appeared desirable to give him Para grass until he completely recovered. This grass is especially relished by sick animals.

The results thus far obtained indicate that alfalfa hay possesses a feeding value far superior to Para grass for restoring run-down horses to their normal condition. Furthermore, it appears that when a horse has been brought to a normal weight, 60 pounds of Para grass daily will maintain that weight.

The work for the year indicates that alfalfa hay can not be fed in Guam in the same quantity and with the same degree of success as it is fed in colder climates. For the station horses kept in the stable but not included in the feeding experiment, a ration of 5 pounds of alfalfa hay and 40 pounds of Para grass has given good results.

NOTES ON PASTURING HORSES.

The average annual cost of maintaining a mature Morgan horse at this station is approximately $140. The data obtained from the pasture tests do not indicate that the cost of feeding can be greatly reduced by using pastures. The *Paspalum dilatatum* on the horse pasture has grown rank even while pastured and still the horses have lost weight. The results from pasturing indicate that native pasturage alone, no matter how large the acreage per animal, will not support Morgan horses.

NOXIOUS PLANTS IN PASTURES.

Horses allowed to run in pastures in which aroma (*Acacia farnesiana*) is growing suffer disagreeable effects from its thorns. The first evidence of injury is the appearance of small beads of blood or blood serum on the surface of the skin of the lips, nostrils, face, and between the pastern of the knee and the hock joints. Next may be noticed swellings resembling those of insect stings. These swellings vary in size from that of a pea to that of a hen's egg. Flies are troublesome, and if careful attention is not given the horses, infection will follow. A considerable swelling occurs in the cheeks, lips, nostrils, fetlocks, and the submaxillary glands. The hair falls out in places, leaving raw sores; in other cases the skin may dry and peel off, giving the face, in particular, a disfigured appearance.

The grass known as "enefuk" (*Andropogon aciculatus*), which has an adherent awn, finds its way into most pastures and is extremely troublesome to horses in that it produces conjunctivitis. A large percentage of the native horses suffer from chronic conjunctivitis due to irritation produced by this grass.

FIG. 1.—PRINCESS ANGELINE, MORGAN MARE, IMPORTED IN 1911.

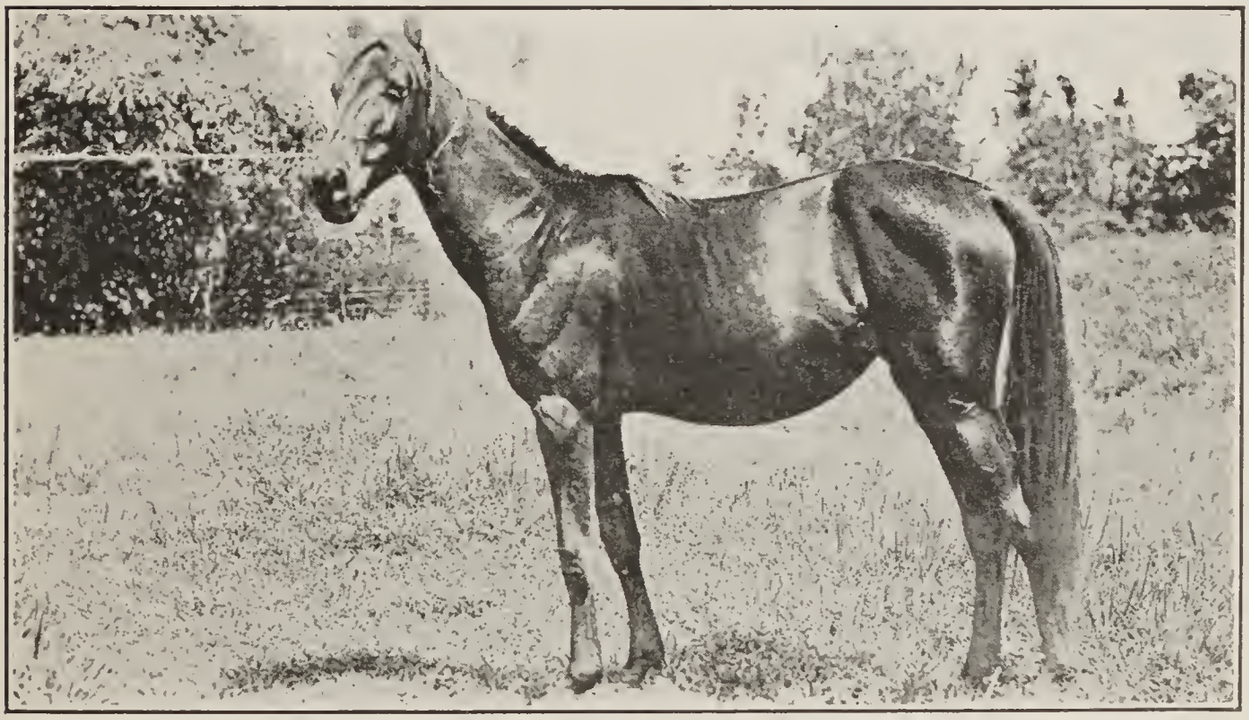

FIG. 2.—DIXIE CASSIUS, MORGAN FILLY, 19 MONTHS OLD. WEIGHT, 510 POUNDS.

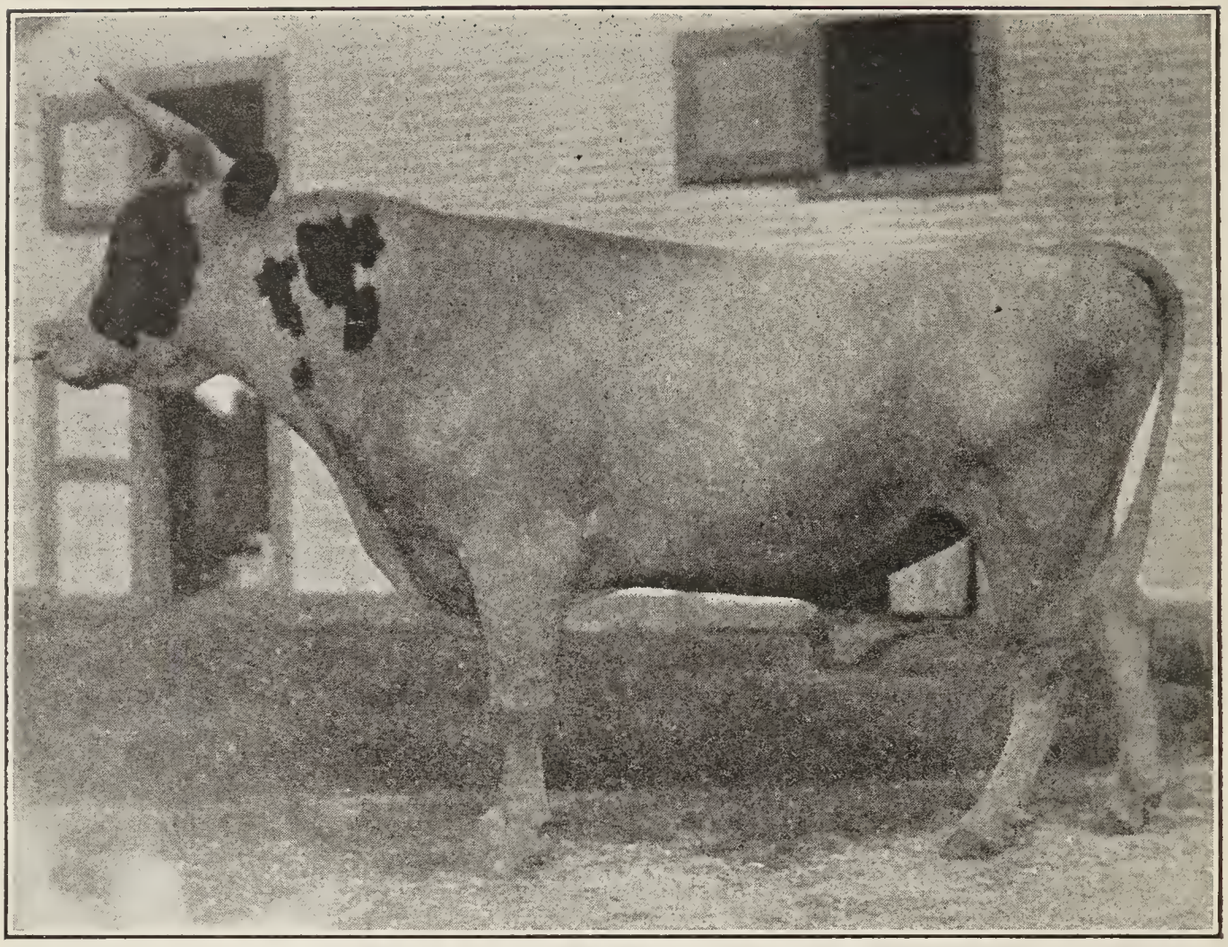

FIG. 1.—JOHN GRAY, IMPORTED AYRSHIRE BULL. WEIGHT, 1,485 POUNDS.

FIG. 2.—WILLOWMOOR RED ROSE, IMPORTED AYRSHIRE COW. WEIGHT, 910 POUNDS.

CATTLE.

PURE-BRED AYRSHIRES.

The original importation of Ayrshire cattle in October, 1911, consisted of 2 bulls, 1 bull calf, and 2 cows. One of the bulls died "from what was believed to be Texas or tick fever"[1] in December, 1911, a little more than two months after his arrival. The next loss was that of the Ayrshire bull, Netherall King B, in January, 1914. The cause of his death was undetermined.[2] The cow, Queen Bess, was the last imported Ayrshire to die. Her death was caused in March, 1914, by tick fever. Therefore but two of the imported animals are now alive, a bull, John Gray, and a cow, Willowmoor Red Rose.

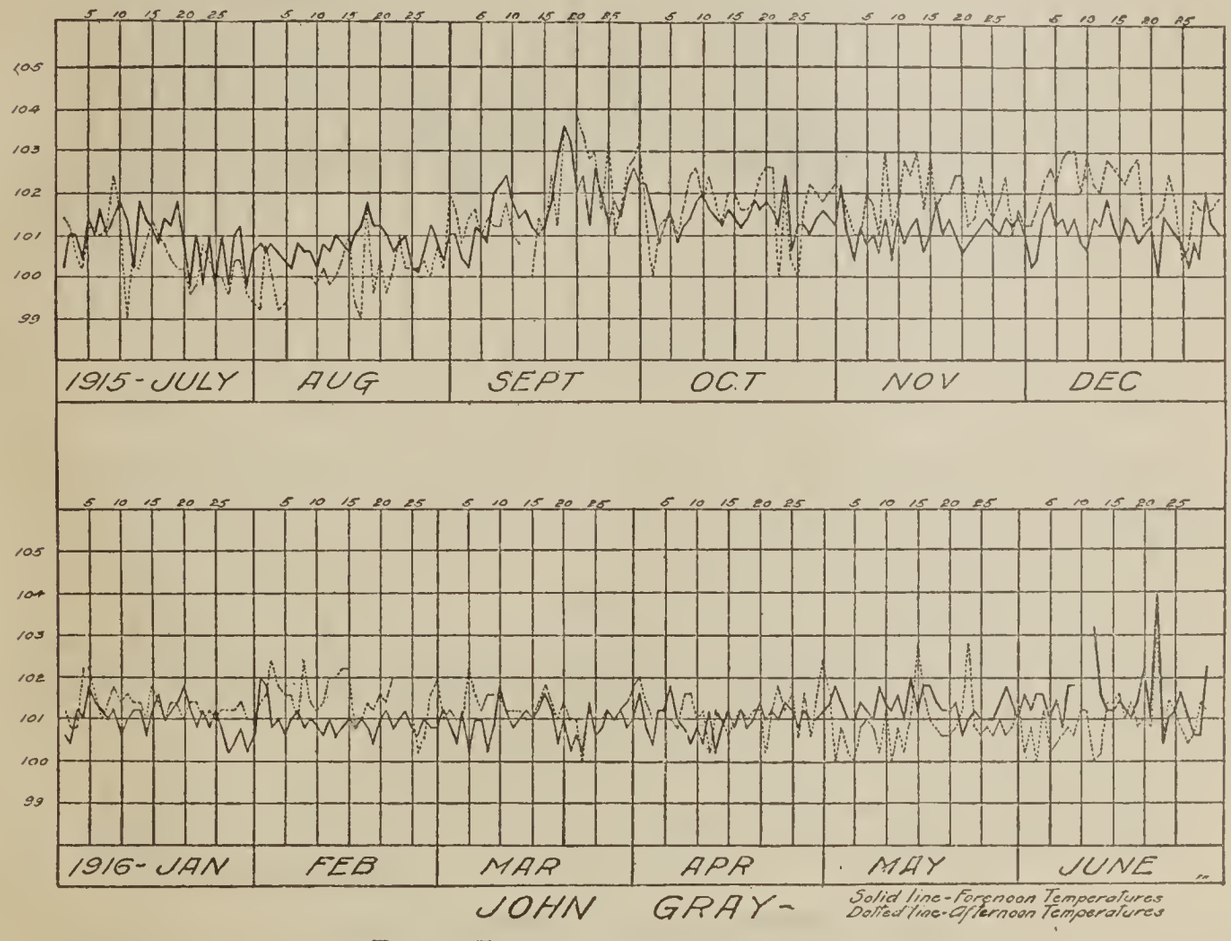

FIG. 1.—Temperature chart of John Gray.

John Gray, as was noted in the last annual report of this station, has suffered several serious attacks of high fever and in every instance it has been possible to trace these to tick infestation (fig. 1). His general health, aside from these attacks, has been good (Pl. VIII, fig. 1). He has proved to be a reliable breeder and his present condition indicates strongly that imported Ayrshire cattle, if kept free from ticks, can be safely brought to Guam.

Willowmoor Red Rose (Pl. VIII, fig. 2) has given birth to only one live calf, namely Guam Island Rose, in October, 1912. In April, 1914, she dropped a permature heifer calf during one of her periods of high temperature. Her condition at that time was most unsatis-

[1] Guam Sta. Rpt. 1912.

[2] Guam Sta. Rpt. 1914.

factory and she was expected to die at any time. During the fiscal year 1915, she lived and that was all, but during the past year her condition has greatly improved and she made a gain in weight of 255 pounds (fig. 2). Red Rose was bred early in this fiscal year and twice afterwards, but was not pregnant on May 24 when she was again bred. The sire John Gray has served her in each case and since he has continually proved his ability to get calves, the trouble is evidently with the cow. Doubtless Red Rose's long sickness accounts for the difficulty experienced in getting her with calf.

Three Ayrshire calves have been born in Guam. Of these Guam Island Rose has already been mentioned. The others are Harry

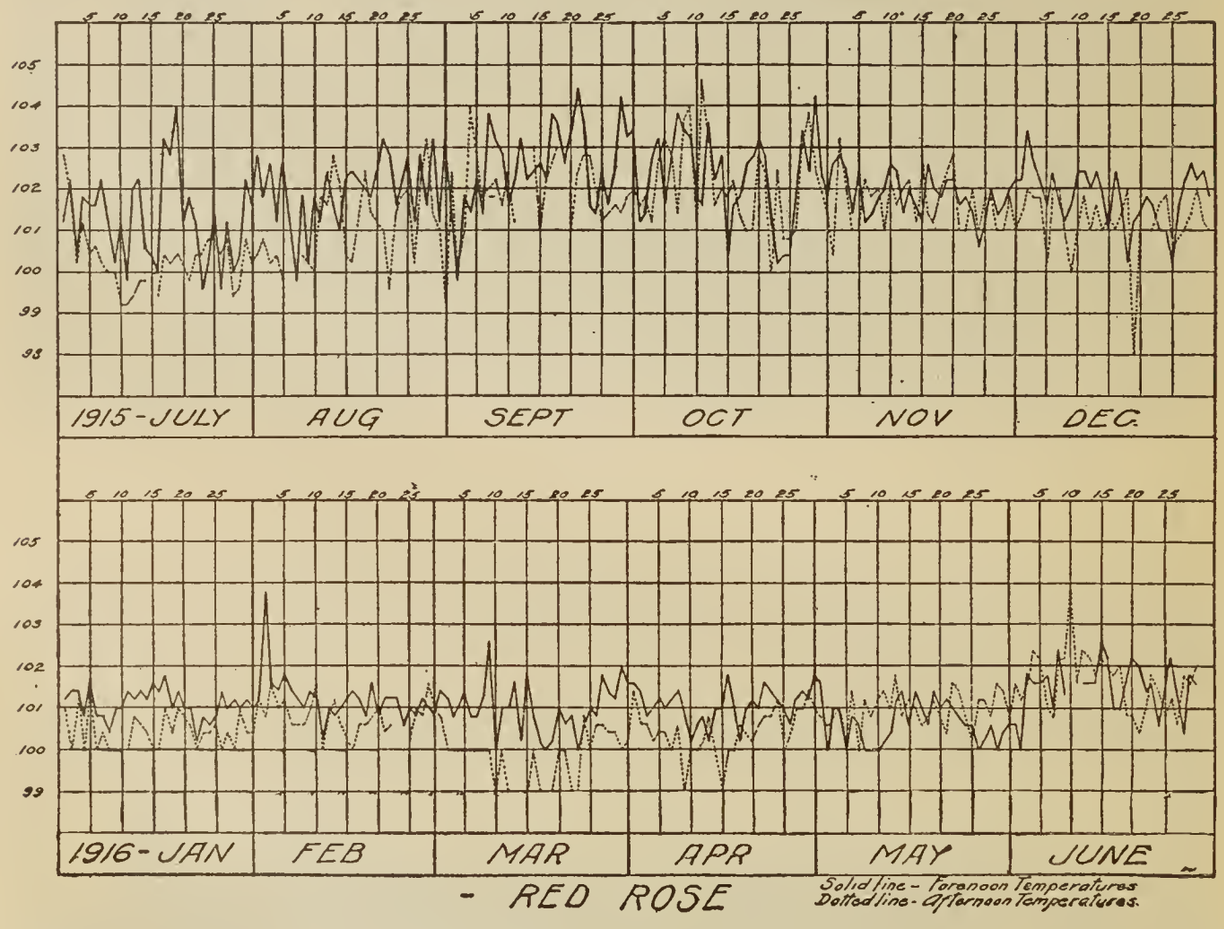

FIG. 2.—Temperature chart of Willowmoor Red Rose.

Gray, born in January, 1913, and Baby Rose, born in February, 1915. Queen Bess was the mother of Harry Gray, and Guam Island Rose, of Baby Rose. Guam Island Rose now weighs 670 pounds and Harry Gray 800 pounds. Both animals are undersized. Until this year, Guam Island Rose has always been more or less infested with ticks and this has certainly been the chief cause of her slow maturity and her low weight. It should also be mentioned that this animal was bred when only 18 months old, in May, 1914, and gave birth to a calf when 27 months old. Her run-down condition owing to the effects of tick infestation during pregnancy must have been a deciding factor in her arrested development. This cow's calf is now 17 months old. Guam Island Rose has been bred three times, but was not pregnant on May 24 and was again bred.

Harry Gray's small size must be charged to tick infestation. When 18 months old he weighed 615 pounds. By December 29, 1914, he had gained only 30 pounds. On that date he was sent to Cotot stock farm and during the six weeks there he lost 145 pounds. When returned to this station in February he had every symptom of tick fever, but as soon as the ticks were removed his condition improved. During the year he has been sent to Cotot stock farm for four 3-week periods, and each time he has lost about 30 pounds, notwithstanding the fact that he has been fed grain, in addition to native pasture and cut Para grass, and sprayed with arsenical dip every 10 days. Dip-

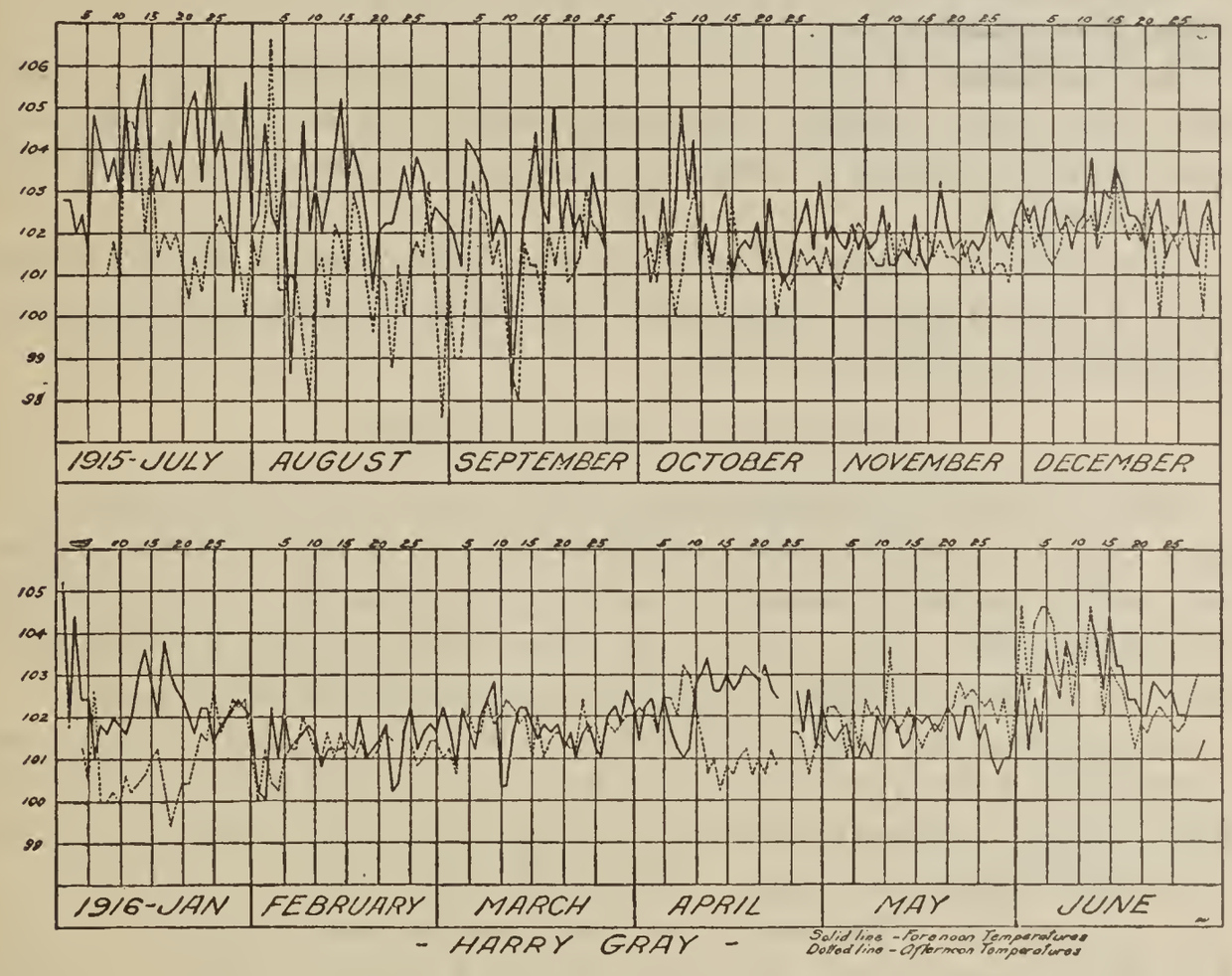

FIG. 3.—Temperature chart of Harry Gray.

ping at 10-day intervals has apparently been insufficient to keep him entirely free from ticks under the natural conditions at Cotot (fig. 3).

Baby Rose, the first calf of the second generation of Ayrshires in Guam, has not been injured by tick infestation, and as a result has made very satisfactory monthly gains. Her weight at this time is 415 pounds, and she has every appearance of a healthy animal.

CROSS-BRED CATTLE.

The average weight of mature native bulls is 690 pounds, and of mature native cows 512 pounds. These weights are based upon 60 animals. Three half-blood Ayrshire bulls bred by this station had an average weight of 597 pounds when 17 months old. John Rhodes, the only half-blood Ayrshire over 3 years old owned by this station,

weighed 818 pounds in June, 1915, when 2½ years old. This bull is now kept at Merizo, where there are no facilities for weighing. This station owns but one mature half-blood Ayrshire cow and her weight June 24 was 810 pounds.

Data of milk production are available on one half-blood Ayrshire heifer, Maria Gray. Her highest milk flow was 8.1 pounds per day, and although she calved in May, 1915, she is still giving milk. This cow's total milk record is higher by 25 pounds than that of the pure-bred Ayrshire heifer Guam Island Rose, and is fully three times that of the average native cow. It should be noted that Maria Gray has never been placed upon a regular dairy ration, having received little more than a maintenance ration.

The hardiness of the cross-bred cattle compares favorably with that of the native cattle. The station half-blood Ayrshire bulls have been placed in native pastures and have kept in as good flesh as the native cattle.

All in all, the objects sought in the improvement of the native cattle by the Ayrshire importation are being fulfilled and this phase of the work is most gratifying.

EFFECT OF TICK INFESTATION.

Until this year, hand-picking and the oil and kerosene treatment were used for keeping down tick infestation on the Ayrshire cattle, but neither method resulted in keeping the animals even reasonably free from ticks. As a result, the imported Ayrshire animals have had one or more periods of high temperature during each year.

An arsenical dip made in accordance with the formula used in the South against the Texas fever tick has been used at this station since July 1, 1915, and with but one exception the cattle have been free from ticks during that time. The heifer Baby Rose was placed in a new pasture for a few days in April and became slightly infested. The effectiveness of the dip upon imported Ayrshire cattle is clearly shown by comparing the temperature records and the weights of the two imported Ayrshire animals for this year with those of the fiscal year 1914.

Comparative temperatures of two head of Ayrshire cattle before and after use of dip.

Fiscal year.	John Gray.						Red Rose.					
	Temperature.					Weight.	Temperature.					Weight.
	Maximum.	Minimum.	Mean.	Number of days 104° or above.	Number of days 105° or above.		Maximum.	Minimum.	Mean.	Number of days 104° or above.	Number of days 105° or above.	
	°F.	°F.	°F.			Lbs.	°F.	°F.	°F.			Lbs.
1914	107.0	101.0	101.8	12	5	1,173	105.8	100.2	102.8	36	4	600
1916	103.8	99.0	101.18	0	0	1,485	104.6	99.0	102.71	2	0	910

John Gray was 1⅙ years old and Red Rose 2½ years old in October, 1911, when they were imported. On June 30, 1913, Red Rose weighed 718 pounds, or 118 pounds more than on June 30, 1914, that being her highest weight until this fiscal year.

It should be noted that the roughage feed of John Gray was doubled a little more than a year ago, and that Red Rose, when kept in the barn, received a corresponding increase. This has no doubt been of considerable influence in their improvement.

The end of the fiscal year finds both animals apparently normal. In the case of Red Rose there have been few traces of diarrhea, and

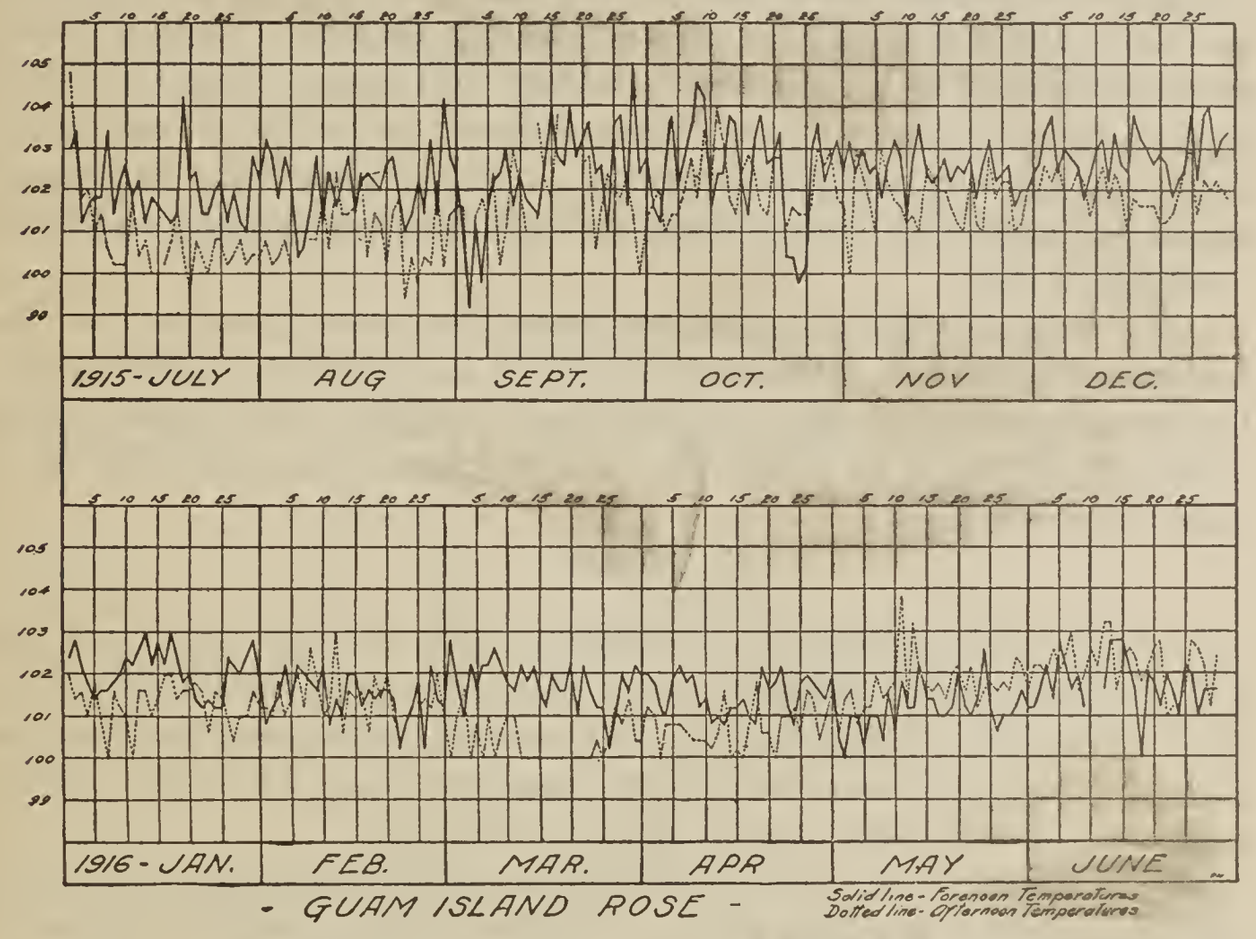

FIG. 4.—Temperature chart of Guam Island Rose.

the jugular pulse is only slightly noticeable at times. Both of these symptoms of the effect of tick infestation were particularly noticeable until this year.

As is shown by her temperature chart (fig. 4), the heifer Guam Island Rose has shown a greater variation in temperature this year than have the imported Ayrshires, although she has been kept under the same conditions as has Red Rose. Although causes previously stated have without doubt interfered with the normal development and health of this animal, it should be noted that her appearance since birth has indicated a lack of vigor. This may probably be credited to the periods of illness which the mother experienced during pregnancy.

NOTES ON HANDLING AYRSHIRE CATTLE.

John Gray during the past year has been kept in a box stall and picketed out only about two hours per day, one hour early in the morning and one hour late in the afternoon. Even a short exposure to the hot sun or a chilling shower in former years has disturbed his normal condition, and the success of the methods of handling practiced this year strongly indicates that an animal which has been kept stabled for several years in Guam must be handled with extreme care.

Red Rose and Guam Island Rose have been allowed to remain in a *Paspalum dilatatum* grass pasture overnight almost all of this year and for the past month have been out during the day. Both of these practices appear to be conducive to their well being. Light showers do not appear to be injurious, whereas exposure to the hot sun invariably results in a rise in temperature. It has been found necessary to provide shelter to protect these animals from heavy rains and from the midday sun.

Baby Rose has since birth been given the same treatment as the half-blood Ayrshires. The only shelter in her pasture is underbrush. During very rainy weather she has been brought to the barn. This heifer is proving to be a far more hardy animal than the other Ayrshires at this station.

HOGS.

Until December, when two Berkshire boars were received from the United States, little progress was made this year in the hog-breeding work. The effects of inbreeding and parasitic infestation had become such that all pigs farrowed for the year preceding December, 1915, were undersized, weak, and of slow development.

Since the new males arrived, it has been possible to place the breeding work upon a new foundation. Four sows have recently farrowed 26 pigs, 22 of the pigs being alive at this time. The pigs had an average weight of 1.47 pounds at birth, and the characteristics of the new sires are fully apparent when the quality of these pigs is compared with that of those farrowed about 15 months previously. Eight of the pigs are half-blood Berkshires, while the others are three-quarter blood Berkshires. Comparative studies of growth, breeding qualities, feeding qualities, disease resistance, etc., of native hogs, of half-blood Berkshires, and of three-quarter blood Berkshires, will, it is hoped, make possible, within a few years, a decision regarding the most desirable amount of Berkshire blood in hogs for Guam.

As yet, there are no definite data on the comparative hardiness of half-blood and three-quarter blood Berkshires. Only 3 three-quarter Berkshires have been brought to maturity, two sows and one boar. During the early part of the fiscal year 1914, one of these sows far-

rowed a large litter of good pigs, while the other farrowed a small litter of inferior pigs. The boar served a few sows, but the pigs obtained were generally inferior. All three of these three-quarter blood Berkshires died from parasitic infestation (Pl. X, fig. 1).

The breeding as now begun will, furthermore, allow rigid selection in the breeding stock placed over the island.

FEEDING EXPERIMENTS.

Breadfruit and coconuts v. corn and shorts.—As noted in the last annual report of this station, an experiment was started on April 28, 1915, to compare a Guam-grown ration of breadfruit and coconut with an imported ration of corn chop and wheat shorts, 10 pounds of Para grass per day being given with each ration. Eight Berkshire-native pigs, four in each lot, were used. The test was run for 140 days, closing on September 15 with the result shown in the following tabulations:

Weights and gains.

Lot No. 1 (Guam-grown feed).	Apr. 28.	Sept. 15.	Gains.	Lot No. 2 (imported feed).	Apr. 28.	Sept. 15.	Gains.
	Pounds.	*Pounds.*	*Pounds.*		*Pounds.*	*Pounds.*	*Pounds.*
Pig No. 75	22	65	43	Pig No. 76	23	79	56
Pig No. 67	30	86	56	Pig No. 72	26.5	76	49.5
Pig No. 68	34	91	57	Pig No. 73	27.2	103	75.8
Pig No. 69	31	92.5	61.5	Pig No. 74	31.4	102.5	71.1
Total weight	117	334.5	217.5	Total weight	108.1	360.5	252.4
Average weight	29.25	83.63	54.38	Average weight	27.02	90.12	63.1

COST OF PRODUCTION.

Lot No. 1:	
Breadfruit, 18 pounds daily, total 2,520 pounds	$12.60
Coconut, 3 pounds daily, total 420 pounds	4.20
Labor, 6 cents per day	8.40
Total cost	25.20
Lot No. 2:	
Corn chop, 4 pounds daily, total 560 pounds	12.60
Wheat shorts, 4 pounds daily, total 560 pounds	9.80
Labor, 4 cents per day	5.60
Total cost	28.00

SUMMARY.

Lot No. 1:		
Weight on Apr. 28, 1915	pounds	117
Weight on Sept. 15, 1915	do	334.5
Gain in 140 days	do	217.5
Average gain per pig	do	54.375
Average daily gain per pig	do	.388
Cost to produce 217.5 pounds of gain		$25.20
Cost per pound of gain		.1158

Lot No. 2:

Weight on Apr. 28, 1915	pounds	108.1
Weight on Sept. 15, 1915	do	360.5
Gain in 140 days	do	252.4
Average gain per pig	do	63.1
Average daily gain per pig	do	.45
Cost to produce 252.4 pounds of gain		$28.00
Cost per pound of gain		.1109

The most important fact brought out by this test was the high cost of a pound of gain, either from the Guam-grown or the imported ration. It was realized when the test was started that the prices of the imported feeds would make the cost of a pound of gain high. It was hoped that the native ration would result in materially lowering that cost, but such was not the case. The data also strongly emphasize the fact that pork production can be made profitable in Guam only by the use of pasture crops. Doubtless pastures may be supplemented with either Guam-grown or imported feeds, but the bulk of the gain in weight must come from the pastures.

Sune, or taro, and coconuts v. corn, shorts, and linseed meal.—A test was started January 1 to determine the comparative cost of producing a 50-pound pig on a Guam-grown ration of sune and grated coconuts, and an imported ration of corn chop, wheat shorts, and linseed meal. Two lots of four sows each were used. At the beginning of the test, the average weight of lot No. 1, which was fed the sune and coconut ration, was 142 pounds, and the average weight of lot No. 2, given the imported feed, was 123.9 pounds. This test had to be discontinued on January 21, but during the 21 days that it was in progress, the sows in lot No. 1 gained 12.7 pounds each, or 0.604 pound per day, at a cost of 7.27 cents per pound of gain, while the sows in lot No. 2 gained 13.5 pounds each, or 0.643 pound per day, at a cost of 7.85 cents per pound of gain.

NOTES ON PASTURES FOR HOGS.

Opportunity was afforded during this year to make a limited study of the value of Para grass and of cowpeas as pasture crops for hogs. In November, eight young sows, having an average weight of 99.7 pounds, made a gain of 3.8 pounds each from pasturing 10 days on one-fourth acre of cowpeas. In a second test, approximately one-half acre of cowpeas and 1 acre of Para grass produced an average gain of 19.5 pounds each in eight sows pastured from January 21 to March 16. The cowpeas in the latter test were very inferior, not only in forage but also in grain production.

The investigation has shown the high value of Para grass as a pasture crop for hogs. From weaning time on, it is relished by hogs, and in no case have the station hogs injured the Para stand. During the past few months sows given a light supplementary ration of

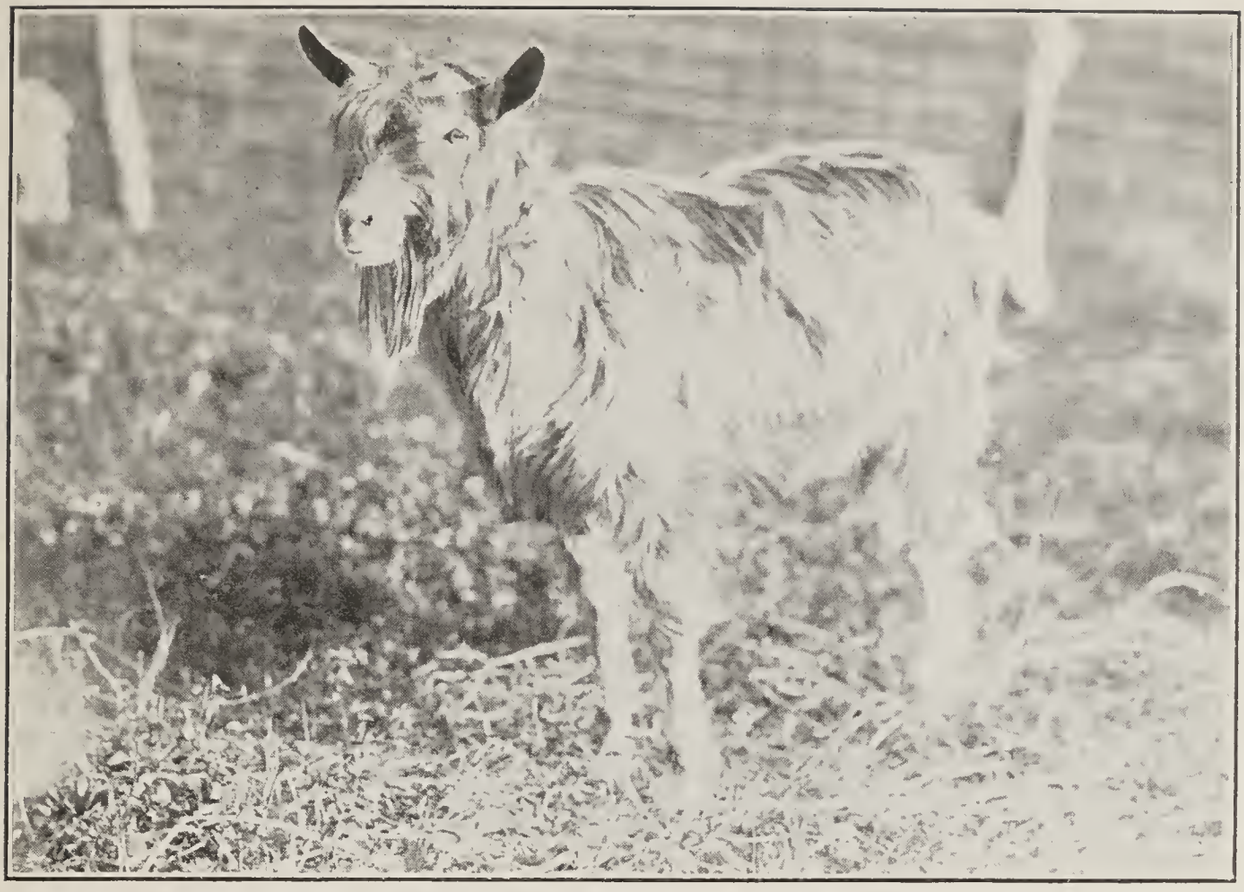

FIG. 1.—BISMARK, PURE-BRED TOGGENBURG GOAT.

FIG. 2.—JAPANESE-NATIVE DOE WITH KIDS SIRED BY BISMARK.

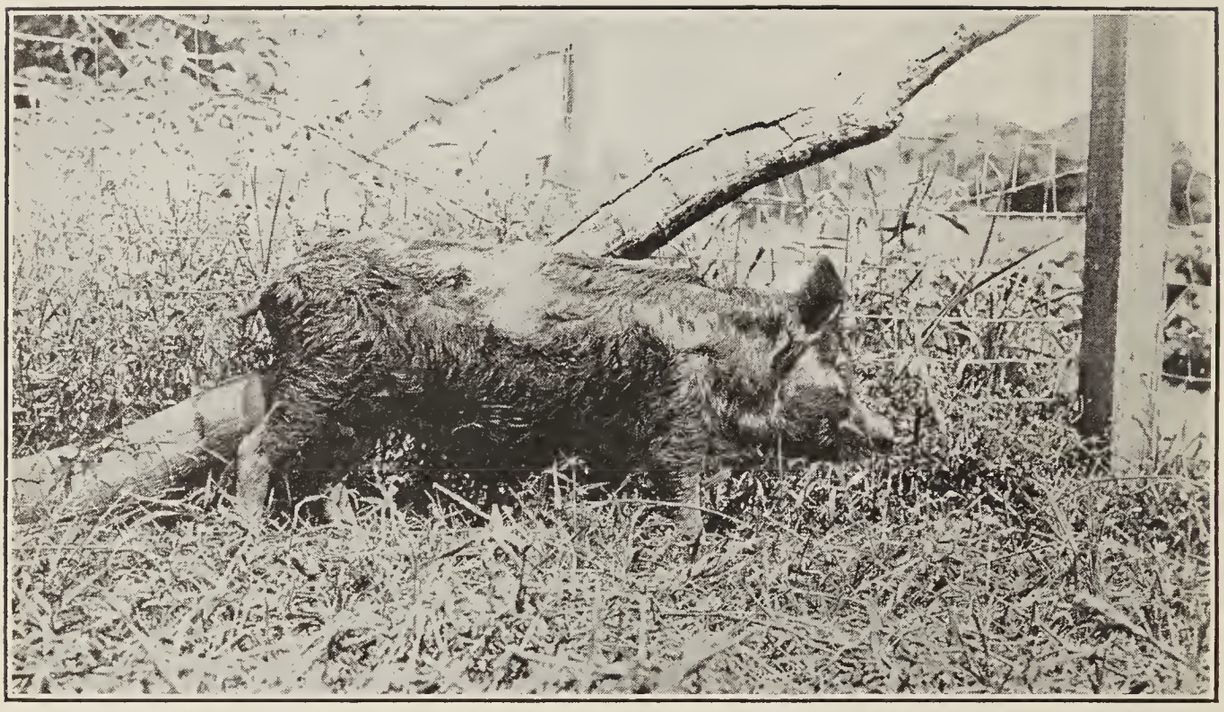

FIG. 1.—BERKSHIRE-NATIVE PIG AFFECTED WITH LUNG WORMS.

FIG. 2.—JAPANESE-NATIVE KID AFFECTED WITH NODULAR WORM.

breadfruit and coconuts have remained in excellent condition on Para grass. Cowpeas appear to be a good pasture crop for supplementing Para grass, especially during the dry season.

DISEASES.

No new hog diseases were found during the year, but opportunity was afforded to make a more detailed study of a kidney worm (*Stephanurus dentatus*), a lung worm (*Metastrongylus apri*), and a cecum worm (*Trichuris crenata*). The first two diseases are common among mature hogs, while the last is most serious among pigs under 4 months of age. As both *Stephanurus dentatus* and *Metastrongylus apri* were considered in detail in the last annual report of this station, only the symptoms produced by the cecum worm are included here. The body is emaciated, the skin rough and scaly, while diarrhea is present in the early stages. Post-mortem examination shows the mucous surface of the large intestines, especially that of the cecum, covered with a thick, yellowish crust, removal of which exposes many pitted ulcers, particularly in chronic cases. The parasites in many instances show through the serous coat of the intestines, and a marked cirrhosis of the liver is generally present.

GOATS.

The two pure-bred Toggenburg buck goats imported in December arrived in good condition, and just when it appeared that the work in goat breeding could be started in earnest, the nodular worm disease (*Œsophagostomum columbianum*) and the fourth stomach worm (*Hæmonchus contortus*) appeared in the station herd. Several does with their kids were placed in a large pasture densely covered with underbrush, and four kids had died before the diseases were known to exist. Of the nine kids in that pasture, not one survived.

About one month after their arrival, the imported bucks became seriously infested with intestinal parasites. Bismark, the larger buck, made a satisfactory recovery, and now appears strong and vigorous (Pl. IX, fig. 1). The other buck, Prince, never completely returned to normal. Until his death on May 12, he continued in an emaciated condition and from time to time suffered from diarrhea. While the post-mortem lesions and the detection of Œsophagostomum showed that the nodular worm disease was present, this is not believed to have been the major trouble. Pathological specimens have been forwarded to the Bureau of Animal Industry of this department for study.

Two Japanese-native does recently gave birth to kids sired by Bismark (Pl. IX, fig. 2). These three kids show strongly the father's blood in their large, strong bones, superior size, and color markings. Only two have wattles, but all have horns.

The principal disease to which goats have been subject is the nodular worm disease (Pl. X, fig. 2), producing the following symptoms: Dull and emaciated condition, sunken eyes, anemic mucous membranes, very loose bowels, with bloody feces or containing mucus. On post-mortem examination, the large intestines, especially the cecum, were found studded with nodules, the kidneys anemic and atrophied, and the gall bladder usually greatly distended.

CHICKENS.

The work in chicken breeding, with the pure-bred Brown Leghorns and Plymouth Rocks and the cross-breds numbered 5, 11, and 12, has proceeded satisfactorily. In the breeding flocks as a whole the egg production was increased 44.9 per cent during the year. The Brown Leghorn-native "black-meat" hens, the No. 5 cross, have proved to be particularly good layers. Six of the original 12 hens in this year's breeding flock have an average record of more than 127 eggs. This record is especially large when considered in comparison with that of 42 eggs, the average egg production of the six best record native hens at the station.

Laying and breeding flocks of all pens are being established and with the trap-nest records this should enable selections to be made which will gradually increase the egg production.

Out of the first 17 hatches, more than 100 of the most desirable birds were sold for breeding purposes. Several poultrymen over the island are working with the cross-bred chickens which were originated at this station, and the supply of surplus birds does not nearly meet the demand.

INCUBATION EXPERIMENTS.

From the five breeding flocks, Brown Leghorn, Plymouth Rock, and crosses Nos. 5, 11, and 12, 2,088 eggs were placed in the incubators. From these 702 chicks were hatched. The highest percentage of hatch was 80 and the lowest 58. The highest hatching eggs were laid by hens of the No. 5 cross and the lowest by the Brown Leghorns. When it is considered that, in the case of the Brown Leghorns and the Plymouth Rocks, no new blood was introduced from 1911 until December, 1915, it is not surprising that the inbreeding resulted in a high percentage of infertility and a low percentage of eggs that hatched. As has been noted, new males were received from the United States in December, and from the time the new blood was introduced until April 1, when incubating was discontinued, the percentage of infertility decreased and that of eggs hatched increased (fig. 5). The following table summarizes these points.

Effect of inbreeding poultry on fertility of eggs.

	Fertility.		Eggs hatched.	
	Brown Leghorn.	Plymouth Rock.	Brown Leghorn.	Plymouth Rock.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Old blood	26	46	53	57
New blood	67	69	74	71

As the intensity of the inbreeding of these two breeds is overcome the infertility should be gradually lowered and the percentage of eggs that hatch should be increased. Sufficient unrelated cocks were

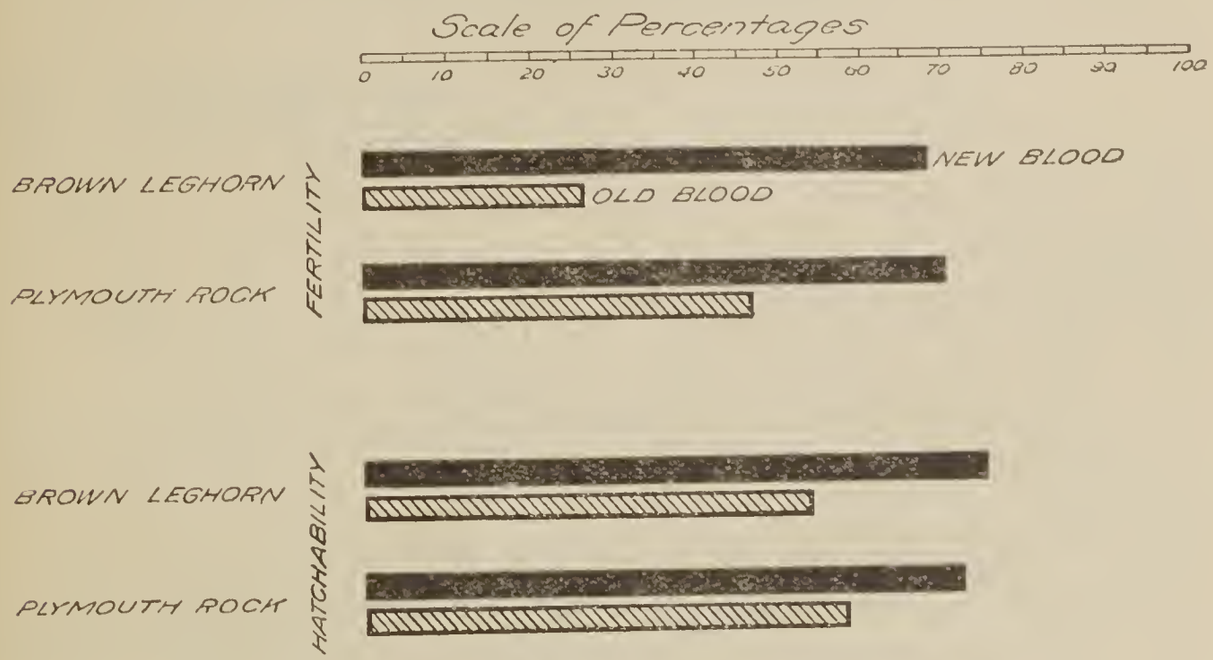

FIG. 5.—Comparative effect of inbreeding on condition of eggs.

obtained in December to permit the introduction of new blood annually for the next three years.

BROODING EXPERIMENTS.

Tests were made with three new methods of brooding, namely, with standard kerosene brooders, with box brooders, and on the floor of the brooder house. The construction of the kerosene brooders need not be considered. The box brooders [1] are 8 by 3 by 1½ feet, and are made of rough 1 by 12-inch pine. Legs at each corner raise the brooders about 2 feet from the brooder house floor. The brooders are completely inclosed except for openings, or doors, 6 inches wide, which run the full length of each brooder on both sides near the tops and are covered with 1-inch mesh chicken wire. The brooders may be built one on top of another. The only accessories are a stand, 1 by 9 by 12 inches, with a drinking fountain for milk at one end and a similar

[1] This type of brooder was apparently first used at the Glenwood substation, of the Hawaii Agricultural Experiment Station. The plan of the brooder was furnished by Mr. J. B. Thompson, formerly of this station.

fountain for water at the other end, and a small tray covered with half-inch mesh wire.

The method of feeding the chicks was the same in all cases. One pound per chick of chick grain feed, was placed on the floor of the box brooder or the brooder house and covered with about 3 inches of rice hulls. This was the only grain feed given during the six weeks the chicks were in the brooders. During the first three weeks, it was supplemented from the tray with a feed composed of 7 parts of bread crumbs and 1 part of hard-boiled eggs, and during the last three weeks with a standard mash. The following table summarizes the results of the tests:

Comparative test of types of brooders.

System of brooding.	Number of chicks.	Actual mortality.	Percentage mortality.	Average weight per chick at 42 days.
				Ounces.
Box brooder	144	12	8.3	7.6
Kerosene brooder	142	23	16.1	8.0
Brooder house floor	154	57	37.0	7.3

No artificial method of heating was used in any except the kerosene brooders, where a temperature of 90° F. was maintained under the hovers.

The rice hulls used resulted in 16 deaths from crop impaction. It is impossible to obtain hulls in Guam which are entirely free from grain, and it has been found advantageous to use unhulled, light rice instead of hulls.

Records from January 1 to June 1 for the interior of one of the box brooders showed a maximum temperature of 91° and a minimum of 73° for the five months. During that time, the average maximum temperature was 86.53° and the average minimum 78.51°. In the box brooders the chicks ordinarily did not appear to be uncomfortable during the day or night except when the thermometer in the brooder registered below 75°. If these brooders are used throughout the year, it appears advisable to equip them with artificial heat.

The kerosene brooder was placed on the brooder house floor and the loss of chicks can be traced to rain beating upon and wetting them. The maximum weight of chicks when 42 days old was in favor of the kerosene brooder chicks.

The work this year when compared with that of 1915 has plainly demonstrated the desirability of keeping the chicks off the ground during the first six weeks after hatching. Chicks so treated seem less subject to attacks of various diseases.

FEEDING EXPERIMENTS.

An imported ration v. a Guam-grown ration for laying hens.—This test was made to determine the relative feeding value of a ration composed of imported feeds and one composed of feeds grown in Guam. Both rations were made up of whole grain and dry mash, the imported whole grain feed consisting of 2 parts wheat and 1 part each of corn and oats, the dry mash of 2 parts bran and 1 part each of corn meal, shorts, and meat scraps; the native whole grain feed consisting of rough rice, the dry mash of 3 parts corn meal and 1 part each of ground cowpeas and meat scrap. The whole grain was fed in litter, while the dry mash was kept before the hens at all times. The following table gives the principal data obtained from September 1 to June 30:

Comparative effects of imported and native rations on hens.

Pen No.	Number of hens.	Kind.	Ration.	Average weight.		Gain (+) or loss (—).	Total number of eggs (10 months).	Average number of eggs per hen.
				September 1.	June 24.			
				Pounds.	*Pounds.*	*Pounds.*		
2	12	Brown Leghorn	Imported	3.0	3.2	+0.2	719	59.9
4	12	do	Native	3.1	3.0	— .1	842	70.2
6	12	No. 11 cross	Imported	3.2	3.6	+ .4	714	59.5
8	12	do	Native	3.5	3.6	+ .1	915	76.3

The small number of hens in the test make definite conclusions impossible, but during the next year, when the pens will be reversed, the result should allow a deduction as to the comparative feeding value for egg production of the two rations.

Grated coconuts for chicks under 6 weeks old.—Tests were made with 214 chicks from seven hatches for which 5, 10, 15, and 20 per cent of grated coconuts was added to the regular ration. In the first trial there was a loss of 38 per cent when the regular feed was used, as compared with losses of 37, 86, and 100 per cent when 5, 10, and 15 per cent of grated coconuts was added to the ration. In the second trial the loss when regular feeding methods were practiced was 4 per cent, and where 5, 10, 15, and 20 per cent of coconut was fed, it was 10, 40, 100, and 100 per cent, respectively.

The inclusion of more than 5 per cent of grated coconut in the ration invariably resulted in producing diarrhea, and when 10 per cent was used, the chicks that recovered from the diarrhea were stunted.

Coconut meal is almost unknown to the people of Guam, the cost of extracting the oil by native methods being too great to make meal production profitable. Most of the chicks grown on the island receive grated coconut as a part of their feed.

DISEASES.

There were only 9 chicks lost from disease during this year, 2 from diphtheritic roup, and 7 from intestinal parasites.

No diseases other than those described in detail in the report for 1915 were observed. That report showed that the young chicks were often badly diseased, and it is gratifying to report that during this fiscal year proper feeding, brooding, and sanitation methods have largely overcome the diseases.

PARASITIC DISEASE STUDIES.

The only parasitic diseases observed during this year, other than those reported in the last annual report of this station, were those of goats. A collection of specimens of all external and internal parasites found has been made for identification.[1] The following list gives the names, both technical and common, of the parasites and of the animal or animals attacked:

External parasites:

Margaropus caudatus, common cattle tick.
Hæmatopinus tuberculatus, carabao louse.
Hæmatopinus suis, hog louse.
Trichodectes climax, goat louse.
Goniocotes gigas, large chicken louse.
Menopon trigonocephalum (*M. pallidum*), common chicken louse.
Dermanyssus gallinæ, red chicken mite.

Internal parasites:

Oxyuris equi, intestinal round worm of horses.
Fasciola hepatica, liver fluke of cattle, hogs, and goats.
Fasciola sp., liver fluke of carabao.
Fischæderius cobboldii, rumen fluke of cattle.
Hæmonchus contortus, fourth stomach worm of cattle and goats.
Stephanurus dentatus, lard worm of hogs.
Metastrongylus apri, lung worm of hogs.
Trichuris crenata (*Trichocephalus crenatus*), cecum whip worm of hogs.
Œsophagostomum columbianum, nodular worm of goats.
Davainea ecinobothrida, chicken tapeworm.
Heterakis (*Ascaridea*) *perspicillum*, intestinal round worm of chickens.
Heterakis vesicularis, cecum worm of chickens.
Tetrameres (*Tropidocerca* or *Tropisurus*) *fissispinus*, stomach nematode of chickens.
Oxyspirura mansoni, eye worm of chickens.
Dispharagus nasatus, stomach worm of chickens.

[1] The station is indebted to Dr. B. H. Ransom, Chief of the Pathological Division, Bureau of Animal Industry, of this department, for identifying all of the parasites and in several cases for a discussion of methods of control.